The Engineer

AUGUST 28, 1953 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

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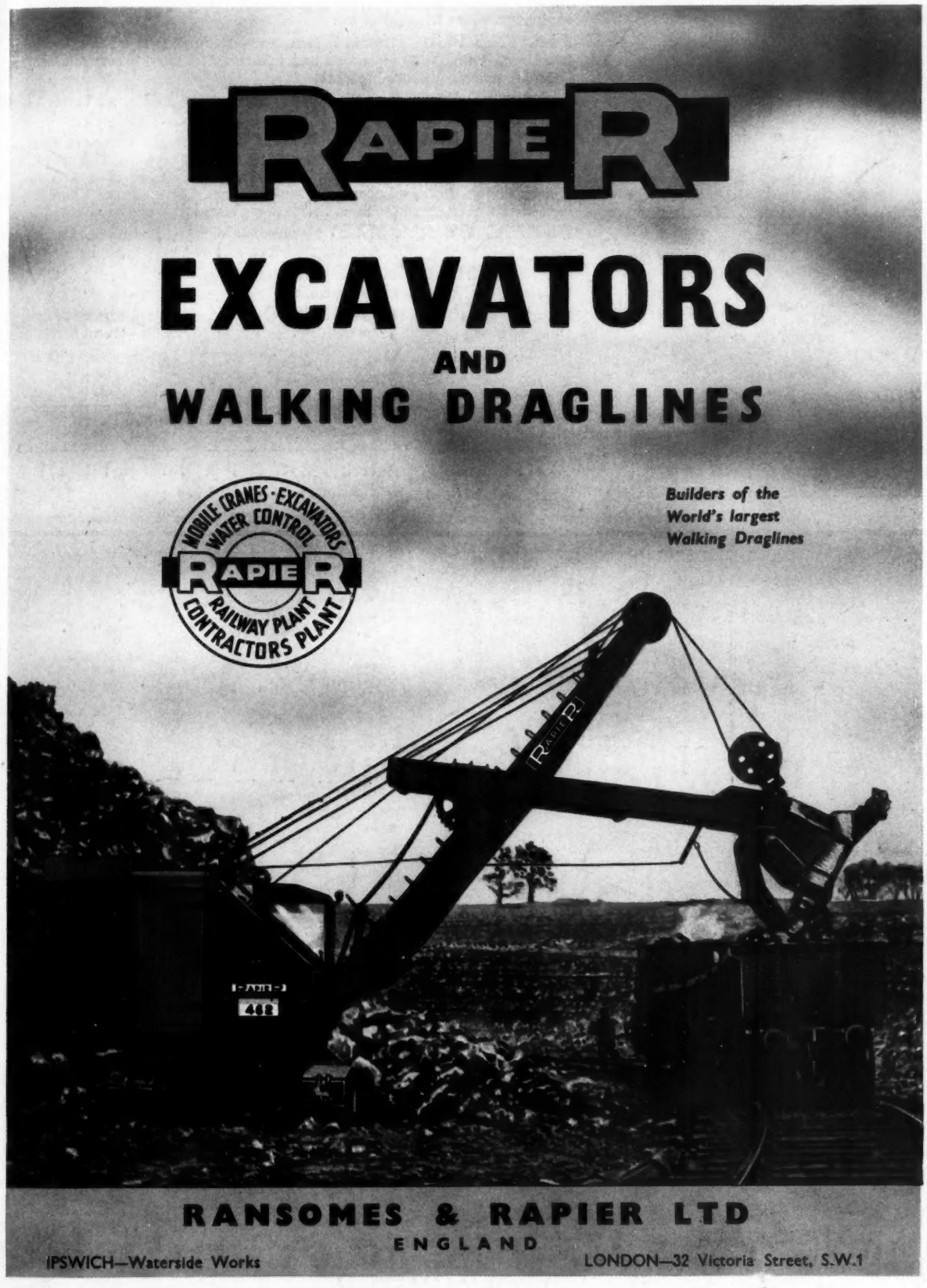

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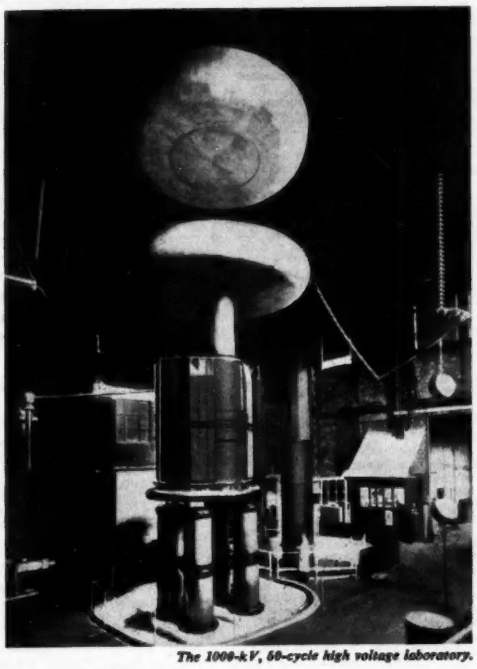

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THE ENGINEER

ESTABLISHED 1856

Vol. 196 No. 5092

AUGUST 28, 1953

28, Essex Street, Strand, London, W.C.2

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

CITY OF CARDIFF EDUCATION COMMITTEE

LLANDAFF TECHNICAL COLLEGE

APPOINTMENT OF PRINCIPAL

Applications are invited for the post of PRINCIPAL of the Llandaff Technical College. Candidates must be Graduates of a British University or hold other suitable qualifications, and should preferably have had industrial experience. Experience in responsible capacity in a Technical College is desirable.

The College, which is to be opened in September, 1954, will provide part-time day and evening courses at Preliminary, SI and SII stages for boys between 15 and 18 years of age employed in building and engineering trades. The Principal will be required to organise the work of the College and to maintain close contact with industry in the area.

The successful candidate will be expected to take up duties on or before 1st January, 1954, and will be required to assist in connection with the preliminary arrangements for the staffing and equipping of the College.

The salary will be £1150 by £25 to £1300 (plus the special addition to salary of £40).

Forms of application, which must be returned not later than 21st September, 1953, may be obtained from the undersigned, Robert E. Presswood, Director of Education, City Hall, Cardiff. E9975

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE

FARNBOROUGH, HANTS

DEMONSTRATOR IN ELECTRICAL ENGINEERING AND PHYSICS

Royal Aircraft Establishment Technical College (selective) requires DEMONSTRATOR in ELECTRICAL ENGINEERING and PHYSICS, to assist in organisation, preparation and control of work in electrical and physics laboratories. A little teaching may be involved. Facilities for research may be available. Qualifications: Degree or equivalent, preferably with industrial experience. Starting salary, according to experience, on scale £375 by £18 to £630 plus £40 special addition and subject to Teachers' Superannuation Acts. Allowances for degree and training.—Details and forms from Principal, to whom completed forms must be returned within fourteen days of this notice. E9994

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

LECTURER IN BUILDING SUBJECTS

The Governing Body invites applications for a post as LECTURER IN BUILDING SUBJECTS. Duties commence as soon as possible.

Candidates must be able to teach some building subjects up to the standard of the Higher National Certificate in Building. Salary in accordance with the Burnham Technical Scale for Lecturers or Assistants, Grade "B."

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed foolscap envelope. Last date for receipt of applications, 14th September, 1953. Applications not on the form provided will be disregarded.

E. C. SMITH,
Principal.

21st August, 1953. E5033

QUEEN MARY COLLEGE

UNIVERSITY OF LONDON
MILE END ROAD, E.1

RESEARCH ASSISTANT IN CIVIL ENGINEERING

Applications are invited from recent graduates for the post of RESEARCH ASSISTANT in the Concrete Laboratory. Work will be on a specified project and will ultimately be made available to the Assistant for use as Higher Degree material. Salary £350 p.a.—Apply as soon as possible by letter to the Registrar. E5049

LONDON COUNTY COUNCIL

SOUTH-EAST LONDON TECHNICAL COLLEGE

SENIOR LECTURER

South-East London Technical College, SENIOR LECTURER in Mechanical Engineering. Good Honours Degree, Corporate Membership of I.Mech.E. or C.E. and good industrial and teaching experience, to teach mainly strength of materials and theory of machines. Burnham salary scale, £1040 by £25 to £1190 plus London allowance.—Application forms from Secretary at College, Lewisham Way, S.E.4, for return by 14th September. (780) E9976

LONDON COUNTY COUNCIL

EBURY SCHOOL, EBURY BRIDGE, S.W.1

TEACHERS

Applications invited from qualified TEACHERS for appointment to Council's service in January and assignment to this Secondary Technical School for 250 boys, 13–17, as master for engineering workshop practice and possibly some mechanical drawing; experience in industry an advantage. Content of course and exceptionally well-equipped workshop offer scope for imaginative teacher.—Apply at once to Headmaster of School on form EO/TS40, obtainable from Education Officer (EO/TS2), County Hall, S.E.1 (send stamped, addressed foolscap envelope). (921) E9990

PUBLIC APPOINTMENTS

GOVERNMENT OF QATAR (PERSIAN GULF)

ELECTRIFICATION OF DOHA

ENGINEER AND MANAGER

Applications are invited for the appointment of ENGINEER AND MANAGER of the State Electricity Department in Doha, under the direction of the State Engineer. The system, which is at present under construction, will include a central power station with two 200kW., two 400kW. and three 550kW. diesel alternator sets with switchgear and ancillary equipment, and a distribution system with overhead lines and underground cables operating at 11kV., 3·3kV. and 415 volts.

Candidates should be Corporate Members of the Institution of Electrical Engineers and must have had previous experience in the administration of similar small electricity undertakings. Practical experience in the planning and construction of distribution systems is also desirable.

Salary Rs. 2130 per Arabic month (present rate of exchange 1 rupee = 1s. 6d.), payable locally, and is at present free of tax.

Appointments are for a period of five years, terminable by three months' notice on either side.

Free air passages are provided for the officer and family on first appointment, on termination of agreement and for leave in the United Kingdom.

Free quarters, with heavy furnishings, water and light, and medical attention will be provided.

Leave is earned at the rate of ninety days per year of residential service and may be accumulated. Earned leave to the United Kingdom may be taken after eighteen months' service.

A knowledge of Arabic would be an advantage.

Applications, endorsed "Engineer and Manager, Qatar," stating age, qualifications and experience, should be forwarded within fourteen days of the date of this advertisement to the undersigned, who will communicate with candidates selected for further consideration.

PREECE, CARDEW AND RIDER.
8 and 10, Queen Anne's Gate,
Westminster, S.W.1. E5019

HER MAJESTY'S COLONIAL SERVICE

DEPARTMENT OF FORESTRY, FEDERATION OF MALAYA

TIMBER RESEARCH OFFICER

Applications are invited for the following post:—TIMBER RESEARCH OFFICER, Department of Forestry, Federation of Malaya.

Candidates should possess Honours Degree in Engineering and preferably be under 30. Specialist experience at a recognised Timber Research Laboratory is desirable, but not essential, as specialist training will be provided. Duties are to take charge of new Timber Research Laboratory at Kepong, where investigations are carried out on Malayan timbers. Appointment on probation for three years for pensionable establishment. Salary in scale £688–£1680 per annum, plus pensionable expatriation pay £182–£364 per annum, and in the case of married officers, non-pensionable expatriation allowance £56–£259 per annum. Temporary, variable, non-pensionable cost-of-living allowance also payable. Government quarters and furnishings, if available, at moderate charges. Generous home leave. Taxation at local rates. Free medical attention. Free passages on appointment and leave for officer, wife and children under the age of 10 (limited to five persons in all on appointment).

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number (CDE.61/60/01). E5018

THE DOCKS AND INLAND WATERWAYS EXECUTIVE

NORTH-WESTERN WATERWAYS DIVISION

DISTRICT ENGINEER

The Docks and Inland Waterways Executive, 22, Dorset Square, London, N.W.1, invite applications for the position of DISTRICT ENGINEER, North-Western Waterways Division (stationed at Wigan), at a starting salary of £875 per annum.

Candidates should be Corporate Members of the Institution of Civil Engineers and have experience in engineering administration and maintenance of waterways, docks or harbours, including maintenance of craft, plant and machinery.

The selected person will, if eligible, be required to join a contributory superannuation scheme.

Applications should be sent to the Secretary at the above address to arrive not later than 9th September, 1953. E5015

NORTH THAMES GAS BOARD

A vacancy exists for an ASSISTANT ELECTRICAL ENGINEER at the TAR and AMMONIA PRODUCTS WORKS, BECKTON, E.6.

Candidates, who should not be more than 35 years of age, should hold a Degree in Electrical Engineering or its equivalent, and have served a recognised apprenticeship. Practical experience in the installation and maintenance of works electrical engineering plant is necessary, and a sound knowledge of and experience in operating high and low-voltage distribution systems would be an advantage. Starting salary within the range £650–£700 per annum.

The appointment is of a permanent nature and the successful candidate will be required to join the staff pension scheme.

Applications, giving age and full particulars, should be sent to the Staff Controller, North Thames Gas Board, 30, Kensington Church Street, London, W.8, quoting reference 666/93. E9988

PUBLIC APPOINTMENTS

SHIPSTON-ON-STOUR RURAL DISTRICT COUNCIL

APPOINTMENT OF RESIDENT ENGINEERS

Applications are invited for the appointments of RESIDENT ENGINEER and ASSISTANT RESIDENT ENGINEER to supervise the construction of about 70 miles of water mains, reinforced concrete service reservoirs and ancillary works.

The work will be executed by contract, under the direction of the Council's Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 18, Queen Anne's Gate, Westminster. The salaries offered are £1000 and £750 per annum respectively, each inclusive of £200 per annum to be considered as a lodging and subsistence allowance, which will not be subject to P.A.Y.E. deduction at source. The appointments, subject to satisfactory service, will last approximately two years and will be terminable by two months' notice in writing on either side.

Applicants, who should have had experience of similar work, should apply in writing to the undersigned not later than 12th September, 1953, giving full particulars of age, qualifications and experience, and enclose copies of not less than two recent testimonials.

A statement should be made by the applicant that he is not related to any member of the Council or staff and has not canvassed anyone in connection with the appointment.

W. BOOTH,
Clerk of the Council.

Council Offices,
Shipston-on-Stour,
Warwickshire,
24th August, 1953. E5043

MINISTRY OF SUPPLY

NATIONAL AERONAUTICAL ESTABLISHMENT, BEDFORD

PHYSICISTS, MATHEMATICIANS AND ENGINEERS

PHYSICISTS, MATHEMATICIANS and ENGINEERS required by Ministry of Supply for Scientific Officer, Experimental Officer and Assistant Experimental Officer posts at National Aeronautical Establishment, Bedford, where facilities for research include powerful new supersonic wind tunnels. Posts in growing establishment offer excellent opportunities for suitable candidates who are interested in working on aerodynamic problems of flight at supersonic speeds. Experience in this field is not essential. Posts graded according to age, qualifications and experience in Scientific Officer Class (requiring First or Second Class Honours Degree or equivalent in Engineering, Physics or Maths.) or Experimental Officer Class (requiring Higher School Certificate (Science) or equivalent; H.N.C. may be an advantage). Houses will be available for rental for successful candidates, if married. Salaries: S.O., £417–£675; E.O. (min. age 26), £649–£799; Asst. E.O. (min. age 18), £264–£576. Women somewhat less. Appointments unestablished. F.S.S.U. benefits may be available for S.O. Class.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A209/53/A. E9993

CIVIL SERVICE COMMISSION

ASSISTANT COMMISSIONER

The Civil Service Commissioners invite applications for a temporary appointment, expected to be for two or three years, to assist in the selection of engineering and technical personnel for permanent appointments in the Civil Service. Starting salary according to qualifications and experience within the scale £1600 by £75 to £1850. Age under 65. Candidates must have a University Degree in Engineering and should preferably be Corporate Members of the Institution of Electrical Engineers. Experience of interviewing an advantage.

Letters of application, stating age, qualifications and experience, should be addressed to the Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, not later than 16th September, 1953. E9991

BRITISH ELECTRICITY AUTHORITY

GENERATION CONSTRUCTION BRANCH, HEADQUARTERS, LONDON

SUPERVISING ENGINEER required, with responsibility to the Generation Construction Engineer, for all construction work at power stations being engineered from headquarters. Those at present in hand are Keadby, East Yelland, Meaford "B," and Willington. Duties entail frequent visits to site and taking the chair at site meetings. Practical experience of all aspects of modern power station construction is essential, and candidates should preferably be Corporate Members of the I.E.E. and the I.Mech.E. Salary will be not less than £1500 inclusive.

Applications, stating age, present position and salary, qualifications and experience, to D. Moffat, Director of Establishments, Winsley Street, London, W.1, by 12th September, 1953. Quote reference E/409. E9979

RESEARCH LABORATORIES, LEATHERHEAD

SENIOR ASSISTANT ENGINEER required, to carry out testing, development and research work in connection with electricity generation. Candidates should preferably have an Honours Degree in Electrical or Mechanical Engineering. Research experience on steam turbine plant will be an advantage. Salary N.J.B., Grade 1, £954–1328.—Forms from D. Moffat, Director of Establishments, Winsley Street, London, W.1, to be returned by 12th September, 1953. Quote reference E/412. E9980

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT CIVIL ENGINEERS

Air Ministry require ASSISTANT CIVIL ENGINEERS for duty in their Works Department engineering work on construction and maintenance civil engineering and buildings projects (cover barracks, workshops, runways, roads, water sup sewage, drainage works, &c.) on R.A.F. stations civil aviation stations. Appointments incl liability for service overseas. Appointments wil in recruitment grade with starting salary accord to age, viz., £628 at age 25 rising to £875 at age thence by annual rises to £970 per annum. Sala somewhat lower in provinces. Appointments temporary but have long-term possibilities special allowance of up to £1300 a year, according location, is payable in addition to salary during o seas service. Candidates must be natural British subjects. Applicant should hold one of following qualifications: B.Sc. (Eng.) or equivale A.M.I.C.E. or A.M.I.Mun.E., or Sections A an of the Institution of Civil Engineers or the Tesan of the Institution of Municipal Engineers. In ad tion, they should have at least two years' civil en neering experience on the staff of a Governm Department, local authority, or a firm of consult engineers or contractors of good standing. Locat of first appointment arranged to meet candidat wishes as far as practicable.—Application for quoting reference E.50/53A, may be obtained fr M.L. and N.S., Technical and Scientific Register (Almack House, 26, King Street, London, S.W. E9992

NATIONAL COAL BOARD

NATIONAL COAL BOARD invite applicati for the undermentioned superannuable appointme in the Engineering Branch of the Production Dep ment in London.

QUALIFIED CIVIL EBGINEER (salary, depe ing on the qualifications and experience of successful applicant, in a range of £650 to £1250 annum). Applicants should have had not less t ten years' experience in the design of civil engineeri work and particularly reinforced concrete structu (Reference No. TT/675.)

ASSISTANT CIVIL ENGINEER (salary, depe ing on qualifications and experience, in a range £ to £750 per annum). Applicants must have specialist experience in the design and detailing reinforced concrete structures and be actively p paring themselves for a recognised professional qua cation in civil engineering. The appointment will the first place, be to the London Headquarters Offi but good opportunities for obtaining site experie occur from time to time and preference will be gi to candidates who express their willingness to be considered for these field appointments as they ar (Reference No. TT/676.)

Write, giving full particulars (in chronologi order) of age, education, qualifications and experie (with dates), to National Coal Board, Establishm (Personnel), Hobart House, Grosvenor Pl London, S.W.1, marking envelope with the refere T.T. reference number quoted above. Original te monials should not be forwarded. Closing date 2 September, 1953. E9977

FULBOURN AND RIVERSFIELD GROUP HOSPITAL MANAGEMEN COMMITTEE

ASSISTANT ENGINEER

Applications are invited for the post of ASSI ANT ENGINEER at Fulbourn (Mental) Hospi The candidates must have a sound knowledge hospital engineering requirements, including st boilers, heating and hot water services, laun machinery and electrical equipment, and should h an Ordinary National Certificate in Mechanical E neering or an equivalent qualification. The succes candidate will work under the direction of Engineer-in-Charge.

Salary will be on the scale £450 by £15 to £ Whitley Council conditions of service. A hous available at a moderate rent.

Applications, stating age, experience and qua cations, together with the names of two refere should be sent to the Group Secretary, Fulbo Hospital, Fulbourn, near Cambridge. E9978

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARC AND DEVELOPMENT ASSOCIATIO

RESEARCH ENGINEER

The Parsons and Marine Engineering Turb Research and Development Association require RESEARCH ENGINEER for the development specialised measuring apparatus used in connecti with research on steam and gas turbine machin The applicants should have an Honours Degree Electrical Engineering or Physics and should h industrial and laboratory experience in electron techniques as applied to mechanical engineeri A good salary will be paid, depending upon a qualifications and experience.—Candidates shou apply in writing to the Research Director, Parsons Research Station, Wallsend-on-Tyne. E5016

THE MID KENT WATER COMPAN

MAINTENANCE ENGINEER

Applications are invited for MAINTENANC ENGINEER to supervise repairs and maintenan of a number of pumping stations. Applica should preferably have served apprenticeship wi diesel engine makers and some knowledge of pum and electrical plant an advantage. Permane position with superannuation scheme after pr bationary service. Commencing salary £550 p annum; candidates should preferably be 30 years.—Applications and full details to Engineer an Manager, Mid Kent Water Company, Snodlan Kent. E9967

THE ENGINEER

AUGUST 28, 1953

Refresher Course for Works Engineers

THE Ministry of Fuel and Power has announced that a refresher course for works and plant engineers is to be held at Brasenose College, Oxford, from Monday, September 21, to Friday, September 25, 1953. The opening address will be given by Rear Admiral Sir Sydney Frew, chief fuel engineer, Ministry of Fuel and Power, at 2.30 p.m. on September 21st. The Ministry has pointed out that the efficiency of plant and fuel utilisation can have a real effect on the cost of production and the quality of the product, and with this knowledge in mind the course has been designed to provide engineers responsible for fuel utilisation in industry with an opportunity to bring themselves up to date in fuel efficiency technique. Lectures by experts are to be supplemented by discussion in a syllabus which will include the following subjects: economics of fuel selection; combustion control in practice; steam generation, usage and peak loads; steam economy in works practice; determination and interpretation of heat balances; compressed air appliances and practices; design, performance and operation of power plant; control of power factor and maximum demand, and waste heat recovery. Lecturers will pay particular attention to practical applications and the course will include a visit to the Morris motor works at Cowley. The fee for the course will be £2 10s., and those desiring accommodation can obtain it at the College for a further charge of £4. It is requested that all inquiries about the course should be sent to the Secretary, Fuel Education Joint Advisory Committee, Ministry of Fuel and Power, Southern Region, Whiteknights, Earley, Reading.

Replacement of Ships

IN an article appearing in the current issue of the *National Provincial Bank Review* Mr. D. F. Anderson, the president of the Chamber of Shipping of the United Kingdom, has something to say about the problem of fleet replacement, which is the greatest present difficulty of shipowners. He maintains that it is impossible fully to replace a fleet while the depreciation allowance is based on first cost and while the actual cost of replacement may be as much as three to four times the initial cost. To the shipping industry, depreciation assumes a greater importance than to any other, and in support of this statement Mr. Anderson quotes 19 per cent for 1950–51 as the depreciation allowance for industry generally, compared with 64 per cent for shipping. Shipping profits, he continues, are exaggerated, for provision for the replacement of assets must be made before real profits can be made, and at present it is impossible to provide the amount necessary to supplement the depreciation allowance out of taxed profits. Under such conditions slow shrinkage in the size of our mercantile marine is its inevitable fate, and Mr. Anderson goes on to say that, although our Merchant Navy is still the largest, its proportion of world tonnage has steadily dropped from 50 per cent in 1905 to 20 per cent to-day. With regard to the operation of tramp shipping, Mr. Anderson recalls that the industry is based on the carriage of coal cargoes outwards and grain or ore cargoes homewards. However, the decline of coal exports from an annual rate of 37,000,000 to about 11,000,000 tons means that, lacking an alternative bulk commodity, the ships have to make the outward voyage in ballast and so the total costs have to be borne by the inward cargo, which results in increased freight charges on our bulk imports. He also touches upon the turnround of ships and mentions some of the causes of port delays which obtain, despite the capital expenditure on mechanical equipment, and which represent a considerable increased charge due to the much higher day-to-day cost of maintaining a ship in port.

Diesel-Electric Locomotive Performance Tests

A TESTING bulletin *Bulletin, No. 9*, has just been issued by the Mechanical and Electrical Engineer's Department of British Railways upon the performance and efficiency tests of the Southern Region 1 Co-Co 1, 1750 h.p. main line diesel-electric locomotive. The bulletin is arranged so as to display the whole range of capacity, fuel consumption and efficiency of a representative main line diesel-electric locomotive and to allow comparison with other forms of motive power. In addition to the analytical tests in the different notch positions, a separate series of service tests was run in order to examine in detail the relationship between the designed power steps and the conditions in which they were used. According to the report the locomotive tested was as originally designed, but a change of gear ratio was effected between the series of trials, since, at the schedules in current operation, power for acceleration was of more importance than the high-speed performance originally required. To effect this, and also to keep within the permissible limits of heating of the electrical equipment, the gear ratio was altered from 52/21 to 65/17 and two stages of field weakening were provided instead of one. The tests were carried out in two parts, namely, service tests and analytical tests, and both were made on the road with a dynamometer car attached as a testing unit. The bulletin states that trains normally worked by the locomotive were used for the service tests, when efficiency values were assessed, while for the analytical tests loads and notch positions were arranged to cover the speed range applicable to the selected field strength, having regard to the gradient of the route. During the tests records were made of oil consumption and temperature, output of generators, and engine performance characteristics, all of which are graphically recorded in the report. In the conclusion the bulletin indicates that efficiency was maintained over a wide range of train load and running speed, which makes the locomotive very suitable for mixed-traffic working.

British Industries Fair, 1954

AN announcement by the Board of Trade states that this week plans for the British Industries Fair in London from May 3 to 14, 1954, are being put in hand. Part of the plan consists of a campaign to induce more manufacturers to exhibit and to this end many more firms are being invited to take part in the London section of the Fair. In previous years it has been the practice to send formal invitations to about 9000 firms, mostly previous exhibitors, to take space; but this year, according to the statement, the usual formula has been discarded and approximately 30,000 British manufacturers will receive invitations. These will be accompanied by material giving comprehensive information concerning the Fair and what it has to offer. In support of the scheme it is intended to utilise the resources and local knowledge of the Regional Offices of the Board of Trade and, at the London headquarters, staff, experienced in each particular industry's requirements, will be available to give assistance and advice. By this wider approach and local help it is hoped to obtain a substantial increase in the number of manufacturers from the various regions exhibiting at the Fair. This year, the announcement continues, radical changes in the method of reserving space are to be adopted with the object of helping the manufacturer. To this end plans are being prepared indicating the actual sites available in each trade section so that intending exhibitors will be able to choose the location they prefer rather than apply for a specific area and leave the exact site to be decided by the organisers after all the applications have been received. In addition, it is intended to advertise the Fair more widely and plans include increased expenditure upon this item and also upon a co-ordinated publicity campaign in each overseas market of importance to Britain.

Royal Aeronautical Society Awards

THE Royal Aeronautical Society has this year awarded its gold medal to Mr. E. F. Relf for his outstanding contribution to aeronautical science over a period of many years. Mr. Relf was superintendent of the Aerodynamics Division of the National Physical Laboratory from 1925 until 1946, when he became the principal of the College of Aeronautics at Cranfield. He has since returned to the National Physical Laboratory as a consultant. Mr. H. Grinstead has been awarded the Society's silver medal for his outstanding work in aeronautical engineering, and the bronze medal has been awarded to Mr. L. Boddington for work on the development of naval aircraft. Mr. R. E. Bishop receives the British Gold Medal for Aeronautics for his outstanding contribution to aircraft design; the British Silver Medal for Aeronautics has been awarded to Mr. J. E. Gordon for excellent work in the sphere of aircraft structural plastics; and the Wakefield Gold Medal has been awarded to Mr. F. W. Meredith for work in the design of automatic pilots and aircraft instruments. Gold medals for written contributions to aeronautical science have been presented to Mr. P. L. Teed for his paper on "Fatigue of Aircraft Materials, with Special Reference to Microstructure," and to Group Captain E. A. Whitely for his paper on "The Spacing of Aircraft Under High Density Approach Conditions."

British Road Services

THE British Transport Commission has announced that the activities at present conducted on its behalf by the Road Haulage Executive are to be transferred, on October 1st, to an undertaking entitled British Road Services. This undertaking will consist of a board of management under the chairmanship of Major-General G. N. Russell, the present chairman of the Road Haulage Executive. The other full-time members of the board will be Mr. Claude Barrington, Mr. George Sinclair, and Mr. G. W. Quick Smith. Mr. Barrington and Mr. Sinclair are at present members of the Executive, and Mr. Quick Smith has hitherto been its secretary. For the time being, the new board of management will also include Mr. Harold Clay and Mr. Archibald Henderson, who are to act in an advisory capacity for special subjects, but not on a full-time basis. The British Transport Commission says that the board's principal duties will be to carry on British Road Services, with all possible regard to efficiency and economy, pending disposal; to continue to manage such road haulage interests as may be retained by the Commission; to assist the Commission in connection with the formation and disposal of transport units in accordance with the Transport Act, 1953, and to ensure during that process the least possible disturbance of the country's road transport system. The statutory instrument to be made in due course will provide, among other things, that all the rights and liabilities of the Road Haulage Executive will become the rights and liabilities of the British Transport Commission.

A Short History of Spectroscopy

By T. W. CHALMERS, D.Sc., M.I.Mech.E.

No. IV—THE THEORY OF THE DIFFRACTION GRATING

(*Continued from page 227, August 21st*)

DIFFRACTION gratings have been used since the early years of the nineteenth century for the purpose of producing and studying luminous spectra.

There are two main types of diffraction grating—the "transmission" and the "reflection." Both consist of a flat or concave surface on which a number of closely spaced parallel straight lines are ruled at equal intervals. There may be 20,000 or 30,000 of these lines to the inch. In a transmission grating the lines are ruled on glass or other transparent substance. In a reflection grating they are ruled on a surface of polished metal such as speculum, silver or aluminium.

A variant of the ruled transmission grating is the "wire" grating, first used by Fraunhofer in some of his early studies. Round two finely threaded screws fixed parallel in a frame Fraunhofer wound a continuous length of correspondingly fine wire. After winding, the wire was stretched by applying a separating force to the two screws. Solder was then run along the screws to fix the wire in the grooves. Finally, all the wire on one face was cut away. Following a long period of neglect interest in the wire grating has revived. It necessarily gives a much coarser grating than can be produced by ruling. Its obvious advantage, however, is that it can be used in a vacuum. So employed it is free from the limitation imposed on the use of a ruled transmission grating by the fact that glass and all other transparent materials are opaque to wave lengths outside certain ranges.

In a ruled transmission grating (Fig. 13), the lines constitute opaque barriers to the passage of light through the grating. The clear spaces between the lines form windows or slits through which the light can pass.* In a wire grating the wires take the place of the ruled lines and the spaces between the wires form the slits. In a reflection grating

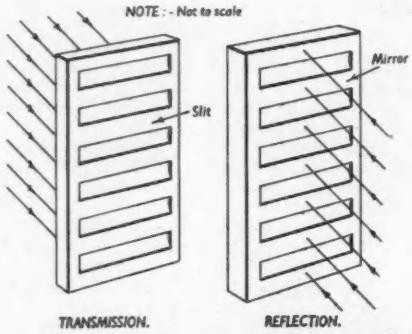


Fig. 13—Transmission and Reflection Gratings

the ruled lines break up the polished metallic surface into a number of elemental mirrors from which the incident light is reflected.

The theory of the ruled or wire transmission grating and of the reflection grating turns upon what happens to the light *after* it has passed through the slits in the one case or been reflected from the elemental mirrors in the other. From this point of view the gratings are fundamentally similar. To an observer on the right—as drawn in Fig. 13—the slits and the elemental mirrors are lines from which a series of light rays emerge towards him. The action of the grating turns upon the manner in which the emergent rays interfere with or reinforce one another. That being so we are not primarily concerned with the means by which the emergent rays are produced, whether by transmission through the slits or by reflection from the mirrors.

The full theory of the grating—transmission or reflection—is complex and highly

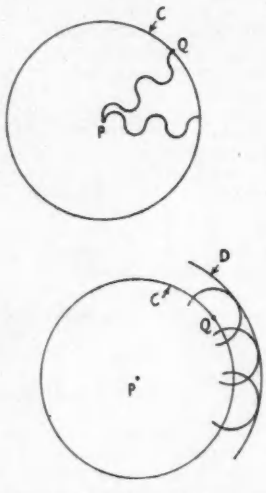


Fig. 14—Huygens' Principle of the Propagation of Light

mathematical. An approach towards it from a geometrical angle can, however, be made by having recourse to a simple principle regarding the propagation of light first enunciated in or about 1685 by the Dutch physicist, Christian Huygens. Huygens disagreed with Newton's view that light consisted of a flux of material particles. In common with Hooke and others he contended that light is a form of wave motion, without committing himself definitely to the nature of the medium in which the wave motion took place.

If light is a form of wave motion then, Huygens argued, any such motion originating at a point must spread out equally in all directions, provided it is not impeded in any way and provided the medium in which it is propagated has the same properties in all directions. Hence, if about a point source of light *P*, Fig. 14, we describe a sphere *C* of any radius all the rays emitted from *P* will reach the surface of this sphere simultaneously. If further we assume that all the rays leave *P* in the same phase, they will still be in phase when they reach the sphere. In other words, the wave motion emitted from *P* will have a spherical wave front, a wave front being defined as any surface over which the wave motion at all points is in the same phase.

Huygens' principle asserts that all the points on the surface of the sphere such as *C* become themselves point sources of light from each of which wave motion is emitted in the same way as that emitted from the original point *P*. If, therefore, we describe about all points on the sphere *C*, such as *Q*, elemental spheres of radius equal to the wavelength of the light, these spheres will all be enclosed within a spherical envelope *D*. This sphere will be the next succeeding wave front after *C* of the wave motion emitted from *P*. All the points on the surface of the sphere *D* become in turn point sources of light and therefore we can repeat the construction. We thus get a picture of the wave motion starting at *P* expanding in an ever-widening series of spherical wave fronts, the wave motion at all the wave fronts being in the same phase at any instant.

Huygens' principle, although it may seem simple, has proved to be remarkably fruitful in providing an explanation of many optical phenomena, including reflection, refraction, diffraction and polarisation. It is applicable also to other forms of wave motion. An obvious application is to water waves and to the manner in which they spread out circularly from a point of disturbance in a calm surface.

It may perhaps be felt that Huygens' principle is not really as simple as it sounds. A "point source of light" is as much of an abstraction as a mathematical point and cannot be realised exactly in practice. Again, the assumption that the wave motion from such a point leaves it in the same phase in all directions opens the way to speculation. This much, however, can be said with assurance: the more nearly we approach in practice to the realisation of a point source of light the more accurately and satisfactorily does the application of Huygens' principle provide an explanation of diverse optical phenomena as observed experimentally.

The key to the action of a diffraction grating is provided by Huygens' principle. Let *A* and *B*, Fig. 15, be two adjacent point sources of light in a plane to which *CC* is normal and midway between the two points. Assume that we are dealing with monochromatic light of wavelength λ. Then with *A* and *B* as centres draw two series of circles of radii λ, 2λ, 3λ, &c. These circles, according to Huygens' principle, will represent the successive wave fronts of the wave motions originating at *A* and *B*.

The circles intersect along the line *CC*.

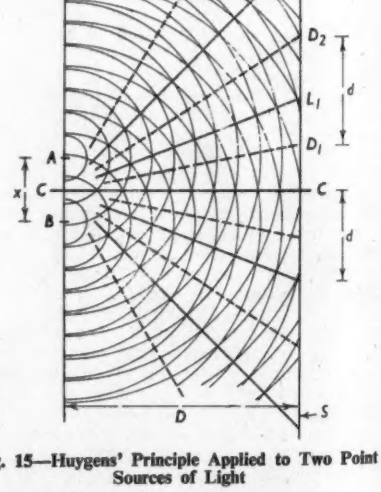


Fig. 15—Huygens' Principle Applied to Two Point Sources of Light

At these points of intersection the wave motion from *A* and that from *B* will, because they are in the same phase, reinforce each other. Hence, looking towards *AB* along *CC*, we will see a superimposed bright image of the points. The circles also intersect along the lines L_1, L_2 and corresponding lines below *CC*. Hence, in the direction of

* Any doubt as to the opacity of the lines will be removed by observing that a scratch on glass seen against transmitted light appears *black*.

these lines bright images of the points will also be seen.

Intermediately along the lines D_1, D_2 the one set of wave fronts will be half a wavelength out of phase relatively to the other set. In these directions the two wave motions will annul each other and therefore no light will be seen. At any point between a bright line L and a dark line D the two wave motions will be partially out of phase—less than 180 deg.—and therefore some amount of light will be seen.

If the points A and B are extended into two parallel lines at right angles to the paper, and if every point on each of these lines acts as a point source of light, we will get the equivalent of a diffraction grating with two transmission slits or two elemental reflecting mirrors. In these conditions a screen placed at S, Fig. 15, will receive the images in the form of parallel alternating bright and dark lines. The lines will not be sharply defined, but will shade from brightness into darkness and from darkness into brightness. The brightest line will be at C. As we pass upwards or downwards from C the brightness of the bright lines and the darkness of the dark lines will diminish until, if we go on far enough, they will fade out completely.

It should be noted that in Fig. 15 the number of bright lines is apparently limited to five and of dark lines to six. This is not a general result, but is merely incidental to the proportions adopted in the figure for the sake of clarity.

The diagram, Fig. 15, shows that the angle between any two adjacent bright—or dark—lines is apparently constant and that the direction of any dark line bisects the angle between the adjoining bright lines. On the screen S, therefore, the bright and dark lines should be equally spaced throughout. That conclusion is confirmed by analysis to a high degree of approximation—see the accompanying mathematical note. It is correct to a still higher degree of approximation if the screen S, instead of being plane, is made concave to a circle about the mid-point of AB as centre.

It follows that there is a simple relationship between the distance d on the screen between any adjacent pair of bright—or dark—lines and the wavelength, λ, of the light originating at A and B. It is found that d is a direct magnification of λ, the magnifying factor being the ratio of the distance D of the screen from the plane of AB to the distance x by which A and B are separated. In symbols the relationship is :

$$d=(D/x)\,.\,\lambda \quad . \quad . \quad . \quad . \quad (1)$$

Hence, by making D considerable and x small—as in a finely ruled grating—the distance d presents us with a very enlarged measure of the wavelength λ.

This is the basis behind the use of a transmission or reflection grating for measuring the wavelength of light. It is also the basis of Young's interference experiments. Young undoubtedly was one of the first, if not the very first, to use a ruled transmission grating—with 500 lines to the inch—but in his original experiments of 1801 he employed two pin holes in an opaque barrier which were virtually equivalent to the two point sources of light A and B in Fig. 15.

With two slits or elemental mirrors extending at AB at right angles to the plane of the paper, the pattern cast on the screen S thus consists, with monochromatic light, of a central bright line flanked on each side by a series of parallel dark and bright lines alternately at substantially equal intervals and of diminishing intensity as we pass outwards from the central line.

We can infer the general effect of using a multiplicity of rulings as in an actual grating by extending the number of slits or elemental mirrors in Fig. 15 from two to four all at a common interval x. The added pair are shown at P and Q in Fig. 16.

The pair AB will act as before. The pair PA being at the same distance x apart will act similarly except that the pattern $LDCDL$ will be displaced upwards by the amount x relatively to the pattern formed by the pair AB. In the same way, the pair BQ will produce the same pattern, but displaced downwards by the distance x. This displacement is negligible because x is very

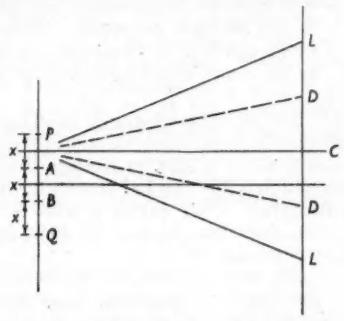


Fig. 16—Action of Four Point Sources

small relatively to the spread d—Fig. 15—of the pattern on the screen. Hence, the effect of the three pairs PA, AB, BQ is to treble the intensity of the bright lines formed by the single pair AB by itself, and slightly to increase their width.

There are, however, three other pairs to be considered, namely, PB and AQ at $2x$ apart, and PQ at $3x$ apart. From formula (1) the effect of doubling or trebling the quantity x is to reduce the distance d to one-half or one-third. Hence, referring to Fig. 15, the two pairs PB and AQ will produce each a bright line at D, where each of the three pairs PA, AB, BQ produces a dark line. The second bright line from each of

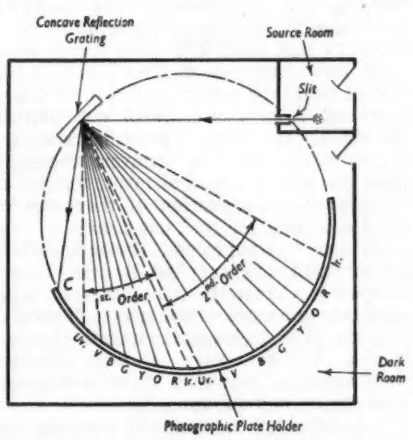


Fig. 17—A Spectrograph Room with a Concave Grating

the pairs PB and AQ will, however—except for a slight displacement amounting to $\frac{1}{2}x$—coincide with the bright line at L_1 produced by each of the pairs PA, AB, BQ.

The final pair PQ will act similarly. Its third bright line will coincide with L_1. Hence all six pairs produce a bright line at C and again at L_1. Between C and L_1 three of the pairs produce a dark line at D, two of them a bright line and one of them a line which is betwixt brightness and darkness.

We can therefore conclude that the general effect of using a multiplicity of slits or elemental mirrors, all at a distance x apart, is to increase, proportionately or more, the intensity of the bright lines in the pattern formed by a single pair. This increase of intensity is, however, accompanied by some diminution in the darkness of the intervening areas between the bright lines, but on balance the contrast between the bright and dark lines is augmented.

It remains now to consider the effect of using with a diffraction grating polychromatic, instead of monochromatic, light. We will deal only with light consisting of a mixture of violet and red, the two extremes of the visible spectrum, of wavelengths 0·000038cm and 0·000076cm, respectively, a ratio of 1 to 2.

At the mid-point C, Fig. 15, the two colours will produce on the screen a line of mixed colouration. From the formula $d=(D/x)\lambda$ the violet component will produce its first bright line at say, L_1 whereas the red component, having twice the wavelength of the violet, will produce its first bright line at L_2. We therefore conclude that a diffraction grating deflects the longest—or red—rays to a greater extent than the shortest—or violet—rays. In that respect a grating acts exactly in a reversed manner to a prism.

Another consideration has to be mentioned. The first bright line of the violet at L_1 coincides with the first dark line of the red. In other words at L_1 we have pure violet unmixed with red. The circumstances at L_2 are, however, different. At this point we have the first bright line of the red. But L_2 also marks the *second* bright line of the violet. Hence, at L_2 the colouration of the line is not pure red, but is mixed with some violet. The mixture, however, leans toward the red side because L_2 marks the second appearance of the violet as against the first of the red and therefore at L_2 the violet has already begun to fade out.

It is not very difficult to extend the argument to points higher up the screen than L_2, nor to study the effect of introducing into the light components of wavelength intermediate between those of violet and red. The general result found is that between C and L_2 the colours form a spectrum in the reverse order of that given by a prism and that at L_2 a second spectrum of diminished intensity begins. At L_2 the end of the first spectrum coincides with the start of the second. As we proceed beyond the second spectrum others of higher order and diminishing intensity appear, but instead of their successive ends and starts coinciding they begin to overlap more and more. Ultimately, the overlapping may proceed so far that parts of three separate spectra may fall on the same area of the screen. The confusion thereby caused is considerable. To avoid it, it is customary in grating spectroscopy to confine attention to the spectrum of the first order or, at most, to that of the first and second.

In Fig. 16 the three primary pairs PA, AB, BQ produce the same pattern on the screen. These three patterns coincide except that the first and third are displaced upwards and downwards by the amount x relatively to the pattern produced by the central pair AB. We treated this displacement as negligible, as is justifiable if x is as small as the spacing between the lines of an actual grating. If, however, we add further pairs of points or lines until we have as many, say, as 20,000 extending over a total distance of an inch, the displacement of the patterns produced by the higher—or lower—pairs relatively to the pattern produced by the central pair AB ceases to be negligible. It would, in fact, in the case mentioned, amount to anything up to $\frac{1}{2}$in.

Any such large displacement would clearly confuse the spectrum formed on the screen. Hence, with an actual grating which may have

ruled lines extending over a total distance of several inches, it is the practice to interpose between the grating and the screen a converging lens which will focus the patterns produced by all the pairs of points or lines of the grating into coincidence on the screen and thereby eliminate the displacement of them all.

The focusing lens naturally absorbs some of the light which it is called upon to transmit. This loss can be avoided by the use of a concave reflection grating. Such a grating acts in the same fundamental manner as a flat grating except for the fact that its curvature produces a focusing effect which renders the use of a separate lens unnecessary.

The plan of an actual spectrograph room in which use is made of a concave reflection grating is given in Fig. 17 (*Classical and Modern Physics*, by H. E. White, Fig. 32H, page 486). In a large dark room there is in one corner a small "source room," through a slit in the side of which the light to be examined is emitted. The light falls on a concave reflection grating curved to a radius of about 21ft. Opposite the grating there is a long curved plate holder lying on a circle of about 21ft diameter. The grating also lies on this circle. By suitably positioning a photographic film or plate on the holder any desired portion of the first or second order spectrum cast by the grating can be studied. The *radius* to which the grating is curved is equal to the *diameter* of the plate holder circle. This relationship results in the spectrum being brought into focus at all points of the plate holder.

Mathematical Note

Theory of Young's Experiment.—Let AB be two points, distant $2y$ apart, emitting monochromatic light of wavelength λ and let P be any point on a screen S at a height z above the mid-point C. Then,

$$BP^2=D^2+(z+y)^2\ ;\ AP^2=D^2+(z-y)^2.$$

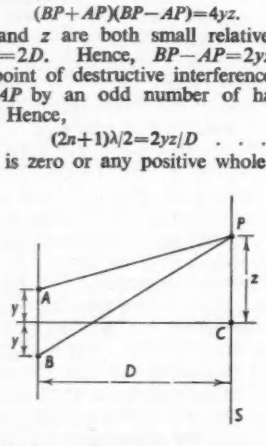
Subtracting,

$$(BP+AP)(BP-AP)=4yz.$$

If y and z are both small relatively to D $BP+AP=2D$. Hence, $BP-AP=2yz/D$. If P is a point of destructive interference BP will exceed AP by an odd number of half wavelengths. Hence,

$$(2n+1)\lambda/2=2yz/D \quad . \ . \ . \ , \quad (1)$$

where n is zero or any positive whole number.



The next higher point of destructive interference will occur at a height z' given by

$$\{2(n+1)+1\}\lambda/2=2yz'/D \quad . \ . \ . \quad (2)$$

Subtracting (1) from (2), writing d for $z'-z$ and z for $2y$, we get,

$$d=(D/x)\lambda \quad . \ . \ . \ . \quad (3)$$

Similarly, if P is a point of constructive interference BP will exceed AP by an even number of half wavelengths, i.e. by any number of whole wavelengths. Hence, corresponding to (1) and (2), we have :

$$n\lambda=2yz/D \text{ and } (n+1)\lambda=2yz'/D$$

Subtracting, this leads to the same result as (3). Hence, any consecutive pair of bright—or dark—lines will be separated by the constant distance d given by (3). Since $AC=BC$ there will always be constructive interference at C. From symmetry every bright—or dark—line above C will be accompanied by a corresponding one below C.

(To be continued)

Resistance Thermometers in the 50 Metre Comparator at the N.P.L.*

By J. S. CLARK, A.R.C.S., B.Sc., D.I.C., and L. O. C. JOHNSON

The 50m mural comparator used at the N.P.L. for the standardisation of surveyors' tapes and wires has recently been modified by the installation of resistance thermometers in place of the mercury thermometers hitherto used to determine the temperature of the tapes. Two types of resistance thermometer have been installed—so-called elongated bulb thermometers, with bulbs 10ft long to give mean air temperatures in the immediate neighbourhood of the suspended tape, and others with bulbs 4in long immured to a depth of 9in into the wall forming the comparator, to give the mean temperature of the comparator itself. The temperature measurements involved in the standardisation of a 100ft or a 24m surveyors' tape of steel or invar can now be carried out with increased accuracy and expedition.

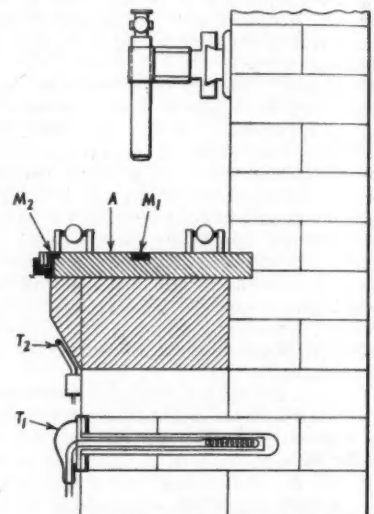
THE 50m mural comparator used for the standardisation of geodetic surveying tapes and wires in the metrology division of the National Physical Laboratory has been fully described in two earlier articles in THE ENGINEER, February 17 and 24, 1950, pages 201–203, and 228–229.

This comparator has recently been modified by the installation of resistance thermometers in place of the ordinary mercury-in-glass thermometers hitherto used to determine the temperatures of the standard tapes, of the other tapes and wires being measured and of the comparator itself. Until recently, when a tape was being standardised "on the flat," its temperature was assumed to be the mean temperature indicated by half a dozen mercury thermometers spaced at about 20ft intervals, lying on the horizontal part of the comparator—the slate bench A in Fig. 1—near the tape. When a tape was being standardised in catenary on the front of the comparator—suspended from rollers near the bench mark M_2 (Fig. 1)—the mercury thermometers were suspended horizontally from the front of the comparator near the tape. In this case the thermometers were not in contact with any part of the wall forming the comparator. An accurate knowledge of the mean temperature of a surveying tape when it is being standardised is of great importance, particularly in the case of steel tape whose coefficient of linear expansion is of the order of one part in 10^5 per 1 deg. Cent. Surveying tapes are usually made of steel or of invar. Standard tapes are usually made of invar, which has a coefficient of expansion of the order of one part in a million per 1 deg. Cent.

The new equipment for temperature measurement was supplied by the Foster Instrument Company. It consists of eight standard resistance thermometer "bulbs" and ten 10ft "elongated bulb" thermometers, together with a 10in edgewise wall indicator mounted on a wall panel with appropriate selector switches.

The standard thermometer consists of a coil of nickel wire wound on a former of length 4in supported in a steel protective sheath of $\frac{1}{4}$in outside diameter and overall length about 10in. The coil is near the closed end of the sheath. The other end of the sheath is flanged. Eight holes, each about 12in deep, were made in the wall forming the comparator, all at a distance of 10in below the slate bench A (Fig. 1). One hole is 12ft from the western end of the bench and one 12ft from the eastern end ; the remaining six are evenly spaced between these two at about 18ft intervals. A thermometer (T_1 in Fig. 1) is fixed in each of these holes in such a way that the flange is flush with the front of the wall, the bulb being effectively immured to a depth of about 9in.

The 10ft elongated bulb thermometer has its coil of insulated nickel wire encased in $\frac{3}{16}$in diameter copper tube. Each of the ten 10ft thermometers is used to determine the mean air temperature over a 10ft length of the comparator, the ten thermometers covering the range 50ft to 150ft measured from the western end of the comparator. This is the part of the comparator normally used to standardise 100ft and 24m tapes. The long thermometers are mounted along the front of the wall forming the comparator



T_1—Immured resistance thermometer.
T_2—10ft elongated-bulb thermometer in section.
A—Slate bench bearing bench marks M_1 and M_2.

Fig. 1—Diagrammatic Cross Section of Mural Comparator

at about 4in below the slate bench A. One is shown diagrammatically in cross section at T_2 in Fig. 1.

The 10in edgewise wall indicator is a moving coil galvanometer with its pivot vertical, having a knife-edge pointer indicating on a 10in scale graduated in tenth degrees from 14 deg. to 24 deg. Cent. It is mounted on a panel, together with the necessary selector switches and all the other electrical equipment, beyond the eastern end of the comparator.

A Wheatstone bridge method is used to determine the change in resistance with temperature of the nickel elements forming the resistance thermometers. Three of the four arms of the bridge are fixed resistances having negligible temperature coefficients ; the fourth arm consists of the thermometer bulb and a length of twin copper cable necessary to connect the bulb to the bridge. The bridge is balanced for a particular

* Communication from the National Physical Laboratory.

temperature near the middle of the range covered by the instrument, and the out-of-balance current through the bridge galvanometer then indicates the temperature of the coil of wire forming the bulb of the thermometer. The calibration of the galvanometer pointer is very nearly linear over the range 14 deg. to 24 deg. Cent. for which the instrument is designed.

A constant-output unit, working on the 240V, 50 c/s a.c. mains, is used for supplying the operating voltage to the Wheatstone bridge. This unit is designed so that a change in the input voltage up to 10 per cent does not produce a change in d.c. output voltage exceeding one part in 400. Hence the maximum error due to mains voltage fluctuations does not exceed $\pm 0{\cdot}0025$ deg. Cent. per degree Centigrade departure from the middle of the range.

The only other source of error is that due to the presence of the copper leads connecting the individual resistance elements to the bridge. The length of twin cable running from the most remote thermometer to the bridge on the indicator panel is about 160ft and has a total resistance of about 2 ohms. The temperature of this wire may vary by $\pm 0{\cdot}5$ deg. Cent., the temperature of the air surrounding the comparator being maintained constant within $\pm 0{\cdot}5$ deg. Cent. The temperature coefficient of resistance of copper wire is about 0·004 per 1 deg. Cent. Hence the maximum variation of resistance in the case of the longest cable is $\pm 0{\cdot}004$ ohm, and since the change in resistance of any one of the thermometer elements is about 0·3 ohm for 1 deg. Cent. change in temperature, the maximum uncertainty due to the variation in temperature of the copper leads is $\pm 0{\cdot}004/0{\cdot}3$, or $\pm 0{\cdot}013$ deg. Cent. The total error due to mains fluctuations and lead temperatures is therefore unlikely to exceed $\pm 0{\cdot}016$ deg. Cent. over the restricted range of temperature which will normally prevail.

Since the length of twin cable running from each individual thermometer bulb to the indicator panel varies considerably, the mean length being about 80ft, it was necessary, when installing the equipment, to adjust to equality the external resistances in each of the eighteen thermometer circuits. This was done by substituting a test resistance of negligible temperature coefficient in each circuit in turn in place of the thermometer, and then adjusting small resistances in series with the connecting leads until all eighteen points read within $\pm 0{\cdot}03$ deg. Cent. of 20·0 deg. Cent. on the indicator when the air temperature was nominally 20 deg. Cent.

The readings of the 10ft thermometers in the neighbourhood of 20 deg. Cent. were

TABLE I

Foster resistance thermometer No.	Length of comparator involved, ft.	Mean difference (Mercury therm.) − (Foster therm.), deg. Cent.	Standard deviation of mean, deg. Cent.
6	50 to 60	0·00	±0·04
7	60 to 70	−0·02	0·04
8	70 to 80	+0·03	0·05
9	80 to 90	+0·01	0·07
10	90 to 100	+0·06	0·07
11	100 to 110	0·00	0·04
12	110 to 120	−0·02	0·08
13	120 to 130	0·00	0·04
14	130 to 140	−0·07	0·08
15	140 to 150	0·00	0·05

then checked against those of mercury thermometers, a single mercury thermometer being attached to each of the long resistance thermometers with its bulb near the middle of the 10ft length. The results of six series of comparisons (ten in the cases of resistance thermometers Nos. 14 and 15) are summarised in Table I.

The mean error of all ten 10ft Foster thermometers was found to be zero with a standard deviation slightly exceeding 0·03 deg. Cent. It is emphasised that these tests relate only to air temperatures in the neighbourhood of 20 deg. Cent. The corridor, about 177ft long, 5ft wide and 12ft high, in which the mural comparator is situated, is air conditioned and it is hoped ultimately to be able to maintain constancy of the air temperature in the corridor at the level of the bench to well within $\pm 0{\cdot}5$ deg. Cent. of 20 deg. Cent. for long periods. But at the time the above calibration was carried out the air conditioning had only just been installed, and during the measurements the air temperature varied from 19·1 deg. to 20·3 deg. Cent. These variations are illustrated in Fig. 2, in which the first two and the last two of the series of results from which Table I is derived are plotted, together with the mean of all the series for each thermometer. The gradient along the bench between 65ft and 125ft (thermometers 7 and 13) was about 0·12 deg. Cent. per 10ft. These conditions are now being improved, but it is

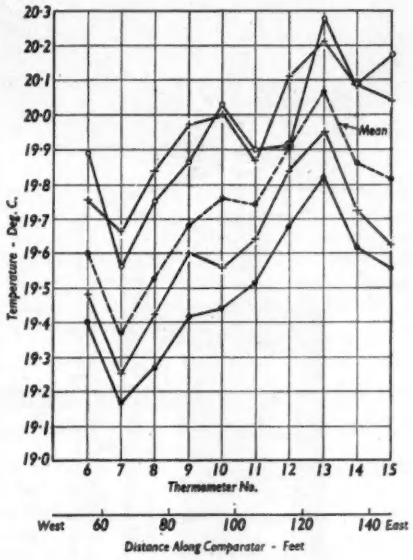


Fig. 2

not expected that the improvement will change the calibration of the Foster thermometers.

Only one of the immured elements was compared with a mercury thermometer. This was done by removing the element from the wall and inserting a mercury thermometer inside the cylindrical former on which the nickel wire was coiled. In the neighbourhood of 20 deg. Cent. both thermometers indicated the same temperature within 0·01 deg. Cent.

Experiments are still being made to adjust the air conditioning so that the air temperature along the corridor in the neighbourhood of the comparator, as indicated by the ten 10ft elongated bulb thermometers, shall be as nearly as possible constant. At the same time, attempts are being made to correlate the temperature of the wall forming the comparator (given by the immured thermometers) with the distance between the 0 and 50m bench marks.

During the first month after installation of the Foster thermometers, but before the air-conditioning plant was brought into full operation, resistance thermometer readings and sag-wire† readings were taken twice daily. The sag-wire readings provide indirect measurements of the changes in length of the 50m base. Some fifty sets of observations covering the temperature range 18·6 deg. to 21·1 deg. Cent. were made. The mean wall temperature, derived from the mean temperature recorded by the eight immured resistance thermometers, was plotted against the length of the bench derived from the sag-wire reading. Allowance was made for the known secular increase in length of the 50m base which is about 0·2mm per annum. All the observations when plotted were found to lie within $\pm 0{\cdot}7$ deg. Cent. of the straight line corresponding with a coefficient of expansion three parts in 10^6 per 1 deg. Cent. Thus, if the mean temperature of the wall be determined by means of the eight immured resistance thermometers, the 50m length of the bench can be calculated with an accuracy of about ± 2 parts in a million. This is obviously not good enough to standardise geodetic tapes to an accuracy of one part in a million, but it represents a fourfold improvement on the accuracy (± 8 parts in a million) previously achieved (albeit over a wider temperature range, 13 deg. to 24 deg. Cent.) by assuming the mean temperature of the bench to be that given by a number of mercury-in-glass thermometers lying horizontally on the bench itself.

Though it is not expected that it will ever prove possible to dispense with the use of standard tapes in measuring other tapes to an accuracy of one part in a million by means of the mural comparator, it is already clear that the necessary temperature measurements of the wall forming the comparator, and of the air surrounding the tapes being measured, can now be carried out with increased accuracy and expedition. It is certainly a great advantage to be able to read off accurately the temperature of any relevant part of the comparator on a single indicator situated at one end of the long corridor.

The installation described above was carried out as part of the general research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

† THE ENGINEER February 24, 1950, page 228.

Pipe-Line Filter Units

SOME years ago, Doulton and Co., Ltd., Albert Embankment, London, S.E.1, introduced a small hard glass filter unit, designed primarily for the laboratory or pilot plant, for use in operations involving the filtration of both corrosive and non-corrosive liquids under negative or positive pressure. Use of this unit has extended also into the field of production processes where, in many instances, several units are employed in parallel in order to achieve increased capacity. In this unit, a porous ceramic filter candle or element, 8in long and approximately 1in diameter, is provided with a glass casing for fitting into a pipe-line.

The company has now developed larger units with similar characteristics. Typical of these new units is one which takes a filter element 18in long by 3½in outside diameter, giving an effective surface area of about 1¼ square feet. The element is encased in a glass tube of 4¾in bore and has inlet and outlet connections at each end of chemical stoneware.

In these pipe-line filter units the liquids passing through have no contact with metal or similar materials of low corrosion resistance. Apart from the porous ceramic element, the stoneware end fittings and the hard glass tube which surrounds the filter, the only other material with which the liquor can have any contact is that which is used for the construction of gaskets. The selection of the most suitable material for gaskets presents a certain problem. They can be of either natural or synthetic rubber, compressed asbestos or certain of the plastics, but all of these have limited resistance to corrosion. The firm informs us that development work is now in progress to find a completely satisfactory material.

The Cornish Pumping Engine

By W. TREGONING HOOPER*

IT is now fairly certain that either this year or next the last two Cornish engines to work in a Cornish mine will be superseded by electrically operated pumps, thus closing a chapter of steam engine history which opened with the erection of the first Newcomen engine in Cornwall in 1712. As the Cornish engine had such a great influence in the development of steam power and economy, it may be of interest to give some details of its progressive development, particularly after 1800.

The prototype of the Cornish engine was the Newcomen engine, which was invented expressly for mine drainage, always the biggest and most costly problem in Cornish mining. Newcomen's engines began to come into general use in Cornwall in the early decades of the eighteenth century ; they were simple and effective, but with a very low thermal efficiency, less than 1 per cent. Two such engines with 66in and 64in cylinders on Wheal Busy consumed 13 tons of coal daily. The average duty in 1777 of a number of engines was 7,037,800 lb of water pumped 1ft high per bushel of coal.

In 1775 the great Smeaton erected a 72in engine on this mine, which gave a duty of about 9,000,000 to 10,000,000. Two years later, on the same mine, James Watt erected his improved engine with an almost twofold increase in efficiency, if not in power. The superior economy of Watt's engines resulted in Newcomen's engines all being converted to the Watt type or superseded entirely. Watt's engines, however, were very limited in power and efficiency by the refusal of Watt to use high-pressure steam ; Watt used pressure of a few pounds per square inch only.

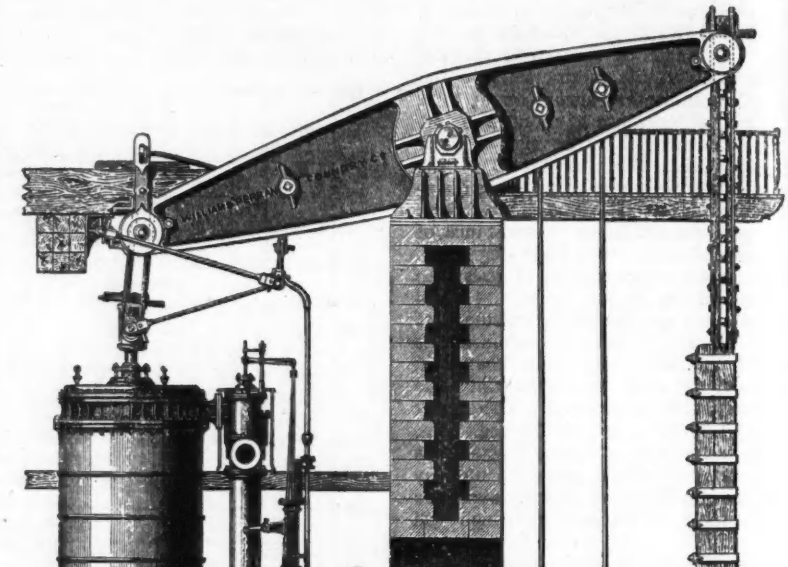
In 1798 a number of Boulton and Watt's engines averaged only 17,671,000 lb per bushel of coal, and his best engine erected about 1799 never gave more than about 20,000,000 foot-pounds or a thermal efficiency of 2 per cent. That represented Watt's supreme performance in Cornwall, and when his monopoly expired he abandoned Cornwall for good. He was never happy in Cornwall, and Cornishmen shed no tears when he departed, but he left behind him an engine " which possessed all the elements of success," and the Cornishmen were not slow to " improve it." Trevithick was the first to realise that power depended on pressure, and he soon had engines working up to 150 lb per square inch : his great contribution, however, was the Cornish boiler, which soon became standard practice.

Watt had never been able with his low pressures to expand his steam, nor was it possible with the use of " bucket lifts " in the shafts ; the use of this type of pump meant that all the water was raised on the upstroke of the pump rod and downstroke of the piston, a dead load necessitating full pressure of steam to the end of the stroke. In 1801 a Captain Joel Lean was appointed manager of a large copper mine, where he found the consumption of coal was enormous; two of Boulton and Watt's engines and one Bull engine averaged under 10,000,000 foot-pounds duty. Lean scrapped all these engines, erected a new 70in engine, and installed plunger pole pumps in the shaft in place of " bucket " pumps, thus permitting his engine to work expansively. His new engine now consumed less than half the previous quantity of fuel. These improvements saved the mine. This was the first Cornish engine and from then on progress was rapid and continuous. The accompanying illustration is reproduced from a catalogue of Williams's Perran Foundry Company, of Perranarworthal, Cornwall, and shows a typical Cornish engine. It was made for the St. Day United Mining Company, " now," according to the catalogue, " called the Poldice Mines," and it is stated that " It has been working under a load of 126,000 lb for the past eight years and in the winter time has been kept continuously at work for six months at an average rate of nearly eight strokes per minute." The date, August, 1870, is added. Our second illustration shows the relics of engine houses at Botallack. The mine workings extended out under the sea.

Space will not permit all the stages to be given in detail, but by 1827 so much progress had been made that an engine designed by Captain Sam Grose and erected on Great Wheal Towan had performed a duty of 87,209,662 lb per bushel of 94 lb of coal, a thermal efficiency of about 8 per cent. Doubts were expressed at the accuracy of the Cornish engines claims ; Sir John Rennie came down on behalf of the Admiralty and in his test he obtained a duty of 92,327,000 ; a little later, Elijah Galloway, C.E., carried out a special trial and computed the duty to be 125,749,330 foot-pounds per bushel (94 lb) of coal. These were values much in excess of those claimed by the Cornish engineers. However, by 1835 an engine at Fowey Consols Mine had, when very carefully tested, performed a duty of 125,095,713 lb per bushel of coal. This was the highest duty ever attained by a Cornish engine and represented a thermal efficiency of about 11 per cent.

It must be understood that the Cornish engine was identical with Watt's engine in construction and the so-called Cornish cycle was inherited from Watt, as Watt had inherited and developed it from the Newcomen engine.

The development of the Cornish engine, however, reached its zenith in 1840 with what is known as Taylor's engine of the United Mines in Gwennap. This engine was built at Perran Foundry ; it had an 85in cylinder and 11ft stroke ; its average duty during 1841 and 1842 was, according to Mr. Farey, 95,750,000 per bushel of coal, and during



Poldice Pumping Engine

* Hon Secretary, Cornish Engines Preservation Society.

Engine Houses at Botallack

one month it averaged 107,000,000 ; it worked continuously with a high duty for thirty years. There is a model of this engine in South Kensington Science Museum.

This is the outline of the story of the Cornish engine, which for scores of years was incomparably superior in efficiency to the best engines in any other part of the world. The world owes a great deal to the engineers of Cornwall, who were the pioneers in steam economy : Hornblower, Trevithick, Woolf, Grose, West, Sims, and Michael Loam ; their names should "be freshly remembered."

Overseas Appointments for Civil Engineers

By C. F. ARMSTRONG, A.M.I.C.E.

No attempt is made here to discuss aspects of going abroad in great detail, but a number of leads are given to help anyone interested in making up his mind more clearly, whether or not to accept any overseas appointment which may be offered. The information is given with the problems of the civil engineer particularly in mind, but some aspects will apply equally well to other engineers or, in fact, to anyone else now considering going overseas.

THERE is always a certain fascination in glancing through the columns of technical journals and the newspapers advertising vacancies overseas. But, apart from thoughts of a change of scene or perhaps a more varied technical experience, this is often as far as the reader gets, especially if he has family commitments and a fairly secure and well-paid job. Nevertheless, there must be many engineers who wish to consider these vacancies more closely, but do not know how to approach the subject with the minimum of wasted effort. There are rather different approaches for junior and senior appointments and special requirements for anyone already on the established staff of the home Civil Service.

It used to be said that a young engineer should decide either to make a career at home or, if he went abroad, be prepared to stay there, as no amount of overseas experience would qualify him for a good job at home in later life. However, the greatly increased use of air travel and of modern engineering plant and equipment throughout the world in recent years has done much to overcome this prejudice. Now, in fact, an overseas job may often provide better opportunities for gaining experience of the latest engineering methods than one at home.

Little will be said about the single man's problems as he has a much wider choice of vacancies than the married man with children perhaps of school age. In fact, if he deletes those problems of the married man which do not affect him and takes note of the others he will not go far wrong. Similarly, the young engineer will have relatively few special problems, but there are two which may concern him. First, having left his engineering college with perhaps no very set idea about the branch of civil engineering he wishes to take up and hoping to try out several in turn, he may find that in the appointment he accepts he is required to specialise in a particular branch. This is more likely to happen if he accepts a specific post than one where he is appointed as a "pupil engineer." Secondly, he may be placed in the position of being able to accept appointment only if his parent or parents go with him. In this case it is wise to find out as much as possible in advance of the effect that this is likely to have.

The choice of appointment lies broadly with government departments, consulting engineers and contractors, or firms selling or servicing civil engineering plant and equipment. There may be openings, too, with the large oil companies and the various port, harbour and railway authorities. Vacancies on the staffs of overseas governments are usually advertised on their behalf either by the Colonial Office, the Crown Agents for the Colonies or the United Kingdom Agents of the Dominions or other governments concerned. Vacancies of the other kinds mentioned are usually advertised in general terms, leaving the applicant to take the initiative in writing to the firm giving particulars of his qualifications and experience and asking for further details of the appointment. Apart from vacancies which are actually advertised, the Institutions of Civil, Mechanical and Electrical Engineers have a Professional Appointments Bureau at 9, Victoria Street, London, S.W.1., which is often able to put young engineers in touch with firms and others wishing to expand their overseas staffs.

If the applicant is already an officer of the permanent staff of the home Civil Service and wishes to apply for a government appointment overseas he will first have to obtain permission from his department to do so. If this is granted he should obtain as soon as possible full details of the terms upon which he would be released. These should cover the questions of retention of seniority, increments, notional promotion, superannuation and, if applicable, continuance of family allowances and National Health Insurance. The advantage of getting these points settled at an early stage is that it enables the applicant to decide whether, in all the circumstances, the terms and conditions offered and imposed by the two governments concerned make acceptance of an appointment worth while.

Other opportunities for overseas duty occur in some departments of the Civil Service, but the officer then remains with his department and the terms of service affecting him will have already been laid down.

Acceptance of Appointments

Before finally accepting an offer of appointment the following points should be given attention.

General.—Although guidance can be given on general matters, it is well to regard even official pamphlets on living conditions, &c., in particular countries as being written in fairly general terms. For help on details nothing can compare with reliable information from someone on the spot and preferably on the staff one is to join. Failing this, contact with anyone on leave from the territory is usually helpful.

Location of Post.—This may be in a town where life is not so very different from that to which one has been accustomed or the station may be quite isolated, involving entirely new standards of living. Some information on the country's politics is also advisable. For instance, is a vigorous policy of development being pursued ? Is a substantial transfer of power to the local government imminent with the consequent possibility of reduction in the security of permanent appointments ? This applies more particularly to government staff appointments.

Climate.—Although there are certain places to which a man may be posted making it advisable for his wife and family to remain at home, the officer will naturally wish to have them with him if at all possible. Generally speaking it will be of advantage both for the officer's wellbeing and his usefulness to his employer that families should not be separated and in borderline cases some risk in this respect is justifiable. The duration of tours of duty is a guide to climate. Appointments on three to four year contracts gener-

ally imply a fairly healthy one, but where the officer is offered home leave at eighteen months or two-yearly intervals a really sound constitution is probably necessary, particularly if the offer is coupled with what appears to be a very high salary for the post concerned.

Standard of Living.—This should not be confused with cost of living mentioned below, nor, however, should it be taken for granted that duty overseas necessarily implies the maintenance of a higher standard of living than that to which one is accustomed at home. This is largely a matter for judgment on arrival to take up a post.

An unchanged standard on a higher salary is a good aim, but sometimes a rather difficult one to pursue. Assuming that excess living costs can be met by cost of living allowances or otherwise, the ease with which it is possible to control expenditure on such things as entertaining depends appreciably on the size of the station or town. In a large town it is quite likely that existing interests can continue to be pursued with little if any additional cost. In small towns or fairly isolated stations the scale of such expenses tends to increase. It is difficult, however, to do more than generalise on this point. For instance, the post may be so isolated that there are few expenses which it is possible to incur. It is more usual, however, in a small community, to have to enter fairly fully into social and other activities with neighbours and this may well add to one's expenses. Admittedly a large town usually offers more scope for spending, but one's social obligations are not necessarily so great. Much, of course, depends on the temperament and inclinations of the individual.

Passages.—Possibly there will be no choice between travelling by sea or air. If such a choice exists some member of a family may have a strong aversion to one form of travel. If not, the deciding factor may be the extent of financial assistance available, or whether or not the whole family can travel together. The total cost of air passages can be estimated very closely. The incidental expenses of a long sea voyage, however, may well eliminate any disparity in quoted fares. In any case if these fares are paid in full by the employer, journey by sea is obviously the more expensive. This can be offset if full or half salary is payable during the journey, but it may be that on first appointment salary is paid only from the date of arrival. If a wife with children has to follow her husband by sea, owing perhaps to uncertainty about future housing accommodation, she will certainly have her hands full, in which case there is much to be said in favour of an air passage.

If the journey involves an extreme change of climate or type of surroundings the necessary mental and physical adjustment must take some time. A sea voyage allows a more gradual change and if other passengers are bound for the same destination there is an opportunity to learn something of the new country beforehand. To be set down in a matter of a few hours some thousands of miles from home in totally different surroundings is likely to entail a mental shock, the severity of which may not be immediately apparent.

Regarding passages home for vacation leave, an agreement may state that leave commences on departure or alternatively on arrival in the home country. Thus, the total period of absence from duty is likely to differ considerably, depending on the means of travel used. Where an assisted or fully paid passage is offered, the agreement may be expected to require repayment of the whole or a proportion of this in the event of the agreement being broken by the employee.

Transport.—Most civil engineering appointments involve the use of personal transport and this may sometimes be provided by the employer, in which case there will probably be restrictions on its private use. Governments may be expected to be stricter than other employers in this respect. If it is necessary to provide one's own transport it is best to choose a vehicle on arrival rather than go to the expense of shipping one which may not prove suitable. Knowledge of the local market is invaluable and it should seldom be more difficult to purchase locally than to order at home for delivery to port of embarkation. Loans may be available either free of interest or at a low rate for purchase of cars to be used mainly for one's job, and this possibility is worth following up.

Housing Accommodation, &c.—Uncertainty about the availability or adequacy of housing or accommodation is probably the most serious problem for engineers wishing to take their families overseas. Sometimes accommodation is promised in the advertisement, but if not the applicant is seldom in the position to make it a condition of appointment. If the local housing difficulties are acute and accommodation except for the employee himself is not guaranteed, permission for his family to accompany him may be conditional upon proof that accommodation is available for them all. Any local contacts are therefore invaluable and this applies also to furniture.

Unless it is definitely confirmed from local information that house furniture, cooking appliances, &c., are either unobtainable or obtainable only at very high cost, it is probably best to sell up and start again. A good deal of new furniture can be bought for the cost of transporting one's own from door to door. This cost is made up not only of the freight charge for the actual voyage, but transport to and from the ports, handling and Customs fees there, and any import duty which may be payable. These ancillary charges often far outweigh the actual freight charge itself.

Gratuity, Pension and Retirement.—If the appointment offered is not with a Government Department it is particularly important to find out what the terms are in respect of pension and similar rights. In the case of firms a superannuation scheme will probably be in force, and if the job is on contract terms some form of gratuity may be offered, payable on termination of the contract. The terms offered by overseas Governments to their staffs are a guide in this connection. Rates vary, but for contract service a gratuity is usually payable and may amount to about 10 to 15 per cent of the gross salary received during the period of service. The calculation may or may not include salary drawn during periods of overseas leave and on voyages.

In the case of pensionable employment there is likely to be a period of probation before the appointment is confirmed and pension rights are established. Similarly a minimum number of years' service will have to be given before a pension is earned. The superannuation scheme may involve deduction of a percentage from salary or it may be non-contributory. The question of any reciprocal arrangement regarding past and future pension rights is often worth pursuing. The age of retirement under a pension scheme should be checked. In the case of overseas Government appointments the retiring age is generally rather lower than at home, in some instances considerably lower. The actual age fixed is likely to bear some relation to the climate.

Salary.—In assessing the gross salary offered account should be taken, in arriving at the net income, of the effect of overseas income tax, gratuity or pension, U.K. income tax and cost of living. Overseas salary scales tend to be rather higher than those at home for the same grade of post, particularly in the case of senior appointments where the offer has to allow for an appreciable incentive. Where the salary has a scale, the point of entry is usually stated to be "according to qualifications and experience." This is therefore entirely a matter where the applicant must use his own judgment. However, if the scale is a long one and he has some specialist experience, it should seldom be necessary to accept the minimum salary offered. It should be ascertained clearly from the agreement what salary, if any, is payable on voyage when taking up a first appointment and when travelling for vacation leave.

An inducement often included in an advertisement is that of low local income tax —say, 2s. in the pound or the equivalent. This is sometimes a material advantage, as indicated in the following example, which also serves to show that, neglecting variations in cost and standard of living, there is sometimes an advantage in taking an overseas job offering no increase in salary. Suppose, for example, an overseas appointment is offered at £1000 per annum on contract terms for four years, followed by six months' leave on full pay, free passages and a gratuity of 10 per cent of the gross salary drawn. Assuming that, owing to income tax allowances, only £500 of the salary is subject to tax at 2s. in the pound, the net income is £950. If the applicant for the post is already drawing £1000 per annum of which, say, £500 is not chargeable to U.K. income tax, his existing net income is £853, calculated at 1953/54 rates as follows :—

	£ s.
Tax on £100 at 2s. 6d.	12 10
£150 at 5s.	37 10
£150 at 7s.	52 10
£100 at 9s.	45 0
Total	147 10 (say £147)
Gross income	£1000
Net income	£853

The applicant in accepting the overseas post would therefore be £821 better off at the end of the 4½ years for the following reason :

	£
Net income overseas—4½ years at £950 ...	4275
Net income in U.K.—4½ years at £853 ...	3838
Difference	437
Add overseas gratuity, 10 per cent ...	£427
Deduct overseas tax on gratuity at 2s....	£43
	384
Total difference	£821

This benefit must, however, be discounted to some extent because even if there is a separate cost-of-living allowance which should be regarded as covering a fair proportion of this expense, it is unwise to assume that it covers the whole excess cost.

U.K. Income Tax.—In spite of low overseas income tax, the consequent obligations in respect of United Kingdom income tax should not be overlooked. If for any reason the officer has to maintain his family at home, his U.K. income tax assessment may be different from that which would be made if he took them with him. It may differ again if he returns home at intervals during a tour of duty overseas. If a saving is made on overseas earnings the question whether these would be regarded as income or capital requires consideration. In any case, if the savings, when remitted home, are regarded not as capital but as income earned overseas and subject to U.K. income tax, less any relief due to local tax previously levied, the

net rate of tax in respect of these savings may differ considerably in amount from the low rate implied in the advertisement. If through delayed sailings or for other reasons outside his control, home leave extends beyond six months, payment of U.K. tax on the leave salary may be demanded. The applicant's bankers should be able to give useful advice on these points.

Cost of Living.—A port handling invoice can be a very enlightening document. Although an article home produced for export carries no purchase tax, it is surprising how many interests take a hand in eliminating this difference in price before it reaches the overseas customer. As a general guide the retail cost of imported consumer goods can be taken as seldom less and often more than the retail price at home (inclusive of any purchase tax). The cost of living thus depends partly on the extent to which it is possible to rely on locally produced goods.

The Temper Mill Drives at the Trostre Tinplate Works

The two-stand temper mills at the Trostre tinplate works of the Steel Company of Wales, Ltd., were the first mills of their kind in this country to operate at speeds of up to 4000ft per minute. In the electrical equipment, almost all of which was supplied by the General Electric Company, Ltd., a cascade control exciter system is applied in conjunction with Ward-Leonard control for maintaining the correct strip tension.

IN the articles we published last year describing the Trostre tinplate works of the Steel Company of Wales, Ltd.,* general notes were given on the two-stand temper mills which impart the desired mechanical properties and prepare the surface of the strip for the subsequent tinning operation. These temper mills were the first to be installed in this country to operate at speeds of up to 4000ft per minute. The General Electric Company, Ltd., supplied almost all of the electrical plant and control gear for them and we have now received from that company details of the cascade control exciter system used in conjunction with Ward-Leonard control for maintaining the correct strip tension in the mills. The consulting engineers for the contract were McLellan and Partners.

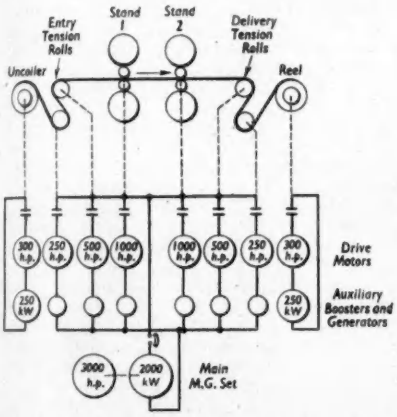


Fig. 1—Arrangement of Rolls and Driving Motors

The two mills are identical and in each of them the work rolls are 18in diameter by 48in wide with back-up rolls 53in diameter by 47in wide. As the steel strip is in a very soft condition when it enters the temper mill, great care is necessary to prevent breakage, wrinkling or buckling, and for this reason each mill has been equipped with two pairs of separately driven tension rolls. A diagram showing the arrangement of rolls and drives for one complete mill is shown in Fig. 1 herewith.

Strip is paid off the uncoiler drum at constant tension and runs over the two entry tension rolls before entering No. 1 stand. The entry tension rolls are designed to increase the tension to a very high value before the strip enters the stand, for if the strip were subjected to this tension when leaving the uncoiler damage might occur. After passing through both stands of the mill and round the delivery tension rolls it is finally recoiled on the reel. The strip is subjected to a combination of high pressure and longitudinal tension as it passes through the stand, and the various physical properties and degrees of temper and finish which can be imparted by the tempering process are controlled by the tension and pressure which is applied, and by the roll surface. The operation reduces the thickness of the strip by an amount ranging from 0·5 per cent to 4 per cent.

For tinplate intended for deep drawing the extension is just sufficient to impart to the strip a close surface suitable for tinning; at the other end of the range, for can body stock, shot-blasted rolls are employed in the first stand to increase the surface work hardening.

Electrical Plant

Each mill is provided with two 1000 h.p. motors for the main stand drives and six motors totalling 2100 h.p. for the tension roll, uncoiler and reel drives. Ward-Leonard control in conjunction with the G.E.C. cascade control exciter system is used for both main and auxiliary drives, and the d.c. power supplies for the motors and control circuits are obtained from nine motor-generator, booster and cascade control exciter sets. Details of the various motors which comprise a complete mill drive are given in Table I.

The d.c. supply for the main stand and tension roll motors is obtained from a 2000kW motor-generator set which is driven at 500 r.p.m. by a 3000 h.p., 11kV synchronous motor, while a 500kW auxiliary motor-generator set driven at 1000 r.p.m. by a 500 h.p., 3·3kV synchronous motor provides the d.c. supply for the uncoiler and reel motors. The booster motor-generator set comprises six d.c. generators with outputs ranging from 21kW to 67·5kW. Each of these machines is connected in series with its corresponding stand or tension roll motor, and the set is driven at 970 r.p.m. by a 250 h.p., 3·3kV, squirrel-cage motor. In addition to these three motor-generator sets six smaller sets are installed to provide supplies for the excitation and control of the mill motors and their associated generators.

The arrangement of the drives of No. 1 mill is shown in Fig. 2. The two main stand motors and the two 500 h.p. top tension roll motors are grouped at the rear of the mill, the 1000 h.p. machines being mounted at floor level and the smaller machines on raised plinths. The two 250 h.p. bottom tension roll motors are situated in pits directly underneath the driving shafts of the top tension rolls. The uncoiler motor is at the front of the mill and the reel motor is at the rear of the mill on the exit side. All the motors are forced-ventilated, the air supplies being derived from separately driven fans mounted in a basement below the mill. For the two 1000 h.p. machines closed air circuit cooling is employed, though provision has been made for some of the air to be exhausted to atmosphere if required. The cooling air for the smaller machines is exhausted to atmosphere. All the motors associated with the mill drives are equipped with thermostats for operating bearing temperature alarm and ventilation alarm circuits.

The 2000kW motor-generator set which

TABLE I—*Motors for the Temper Mill Drive*

Drive	No. of motors	Horse-power	Volts	Speed, r.p.m.
Main drives for Stand 1 and 2	2	1000	0/500	700/950
Top tension rolls, entry and delivery	2	500	0/500	735/1100
Bottom tension rolls, entry and delivery	2	250	0/500	735/1100
Uncoiler	1	300	0/500	185/835
Reel	1	300	0/500	185/835

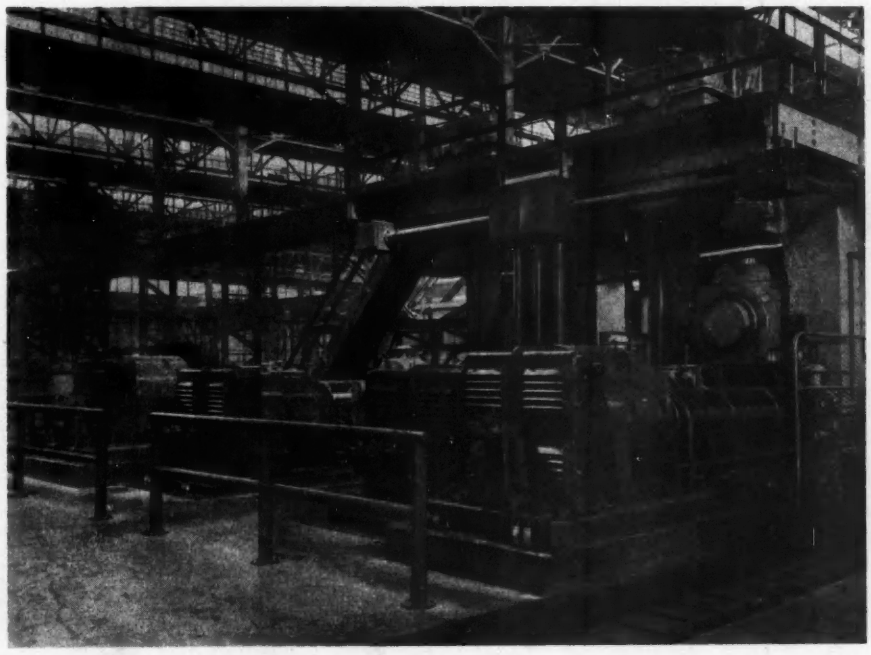


Fig. 2—Temper Mill Drives

* See The Engineer, Sept. 26, Oct. 3 and Oct. 10, 1952.

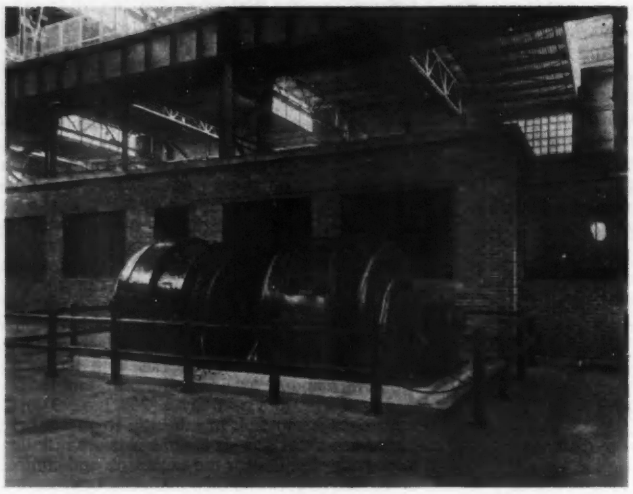


Fig. 3—2000kW Motor Generator Set

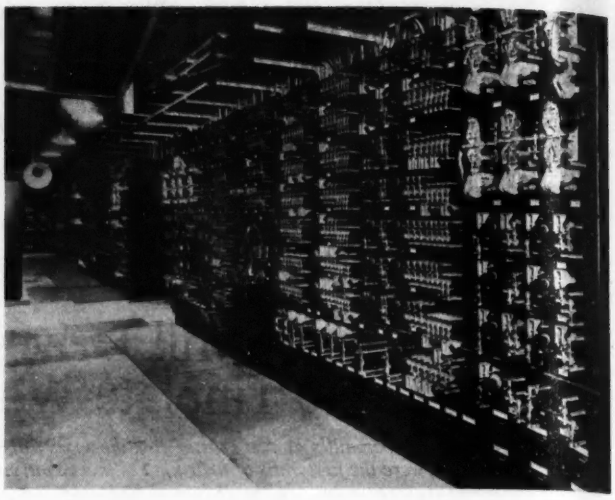


Fig. 4—Main Switchboard in Basement

supplies power to the main stand and tension roll motors is shown in Fig. 3. The synchronous driving motor is provided with closed air circuit cooling and with control gear, which enables either reactor or direct-to-line starting to be employed. A booster set for the stand and tension roll motors is housed, together with the auxiliary motor-generator set for the uncoiler and reel motors and a 120 h.p. constant-voltage exciter set, in a substation adjacent to the mill.

As the mill floor at Trostre is some 14ft above the original ground level, and is supported by reinforced concrete columns, there are basements extending under the whole floor area, which have been used as electrical substations and control rooms. The main control set and the various cascade exciter sets have all been accommodated in the basements and a typical group of cascade sets used for the uncoiler and reel drives is shown in Fig. 5.

Switchgear

The mill is controlled from three cabinets which are hinged to the main stands and contain the necessary instruments, controllers, regulators, and indicating lamps. With the exception of these cabinets the whole of the switchgear for the mill is housed in the basement. The main switchboard, part of which is shown in Fig. 4, is of the flat-back contactor type, which has been used throughout the Abbey and Trostre Works. The alarm panel is a single cubicle of pressed steel construction, and a four-section cubicle of similar design has been used to house the resistors associated with the various control circuits.

The starting equipment for the driving motor of the main motor-generator set, which consists of an oil-immersed reactor and short-circuiting breaker, is housed in other compartments of the basement, together with the 3·3kV circuit breakers controlling the motors of the reel generator and booster motor-generator sets.

Method of Control

An essential requirement of the control scheme is that, irrespective of differences in the loads imposed on the two stand motors, their preset speed ratio must be maintained during acceleration and deceleration of the mill. Similarly, each pair of tension rolls is controlled so that the tension between them and the adjacent stands is maintained at the preset value throughout the acceleration and deceleration periods.

The equipment is so designed that the time taken to accelerate the mill from rest to full speed can be varied from twelve to twenty seconds, whilst the time required for stopping the mill from full speed can be adjusted between the limits of five and twenty seconds. Regenerative braking is normally employed to stop the mill, but a single step of dynamic braking is provided to meet emergency conditions. The speed of the mill as a whole is varied by controlling the voltage of the generators of the motor-generator sets, operation of the "thread" or "run" buttons on the control cabinet causing the mill speed to change to that selected. A "hold" button is provided to enable the mill speed to be maintained at any intermediate value. A further button known as "stand slow-down" causes a slight decrease in the speed of the first stand, thus enabling loops which may be formed during threading to be removed. This speed returns to its previous value as soon as the button is released, and the control does not function at running speeds.

Fig. 5—Control and Exciter Sets

In order to preserve the correct tension in the strip as it passes through the mill, special control exciters, which are rapid-response machines of high amplification, are used for regulating the output of both the main and the auxiliary motor-generators, and for each of the motors driving the stands, tension rolls, uncoiler and reel.

The stand motors are fundamentally speed controlled, with an overriding tension control which is actuated from a tensiometer roll by means of an electronic amplifier. The tension roll, uncoiler and reel motors are fundamentally current controlled, and electronic amplifiers are used only to provide accurate accelerating and retarding torques.

To ensure that the speeds of the stand and tension roll motors follow closely the main generator voltage, boosters are provided to compensate for the resistance drop in the motors and for changes in the diameter of the rolls. Automatic control of the tension between the stands is provided by the tensiometer roll, which supplies a correcting signal to an electronic amplifier from which two of the fields of the pilot control exciter for the first stand drive are energised. Provision is also made for manual control of the strip tension between the two stands.

As the strip passes from the uncoiler to the entry tension rolls and from the delivery tension rolls to the reel, constant tension is ensured under steady speed conditions by controlling the generator excitation so as to maintain a preselected armature current in the motor while varying its excitation, and consequently its torque, automatically in proportion to the reel diameter. During periods of acceleration or deceleration constant tension is preserved by increasing or decreasing the generator voltage to vary the current and torque of the driving motor, the change in torque taking into account the rate of change in speed and the change in the inertia of the reel. The control is such that stalled tension may be maintained when strip is in the mill at standstill. This can be released as desired.

Mill Stands Control

A simplified schematic diagram of the connections for the two stand drives is shown in Fig. 6. In the control of the mill the speed of No. 2 stand driving motor *M5* is treated as the "master" for all the remaining drives. This motor is excited from the constant-voltage line via a setting resistor *R5*, and a booster *B5* is included in the armature circuit to ensure that the speed of the motor will be closely proportional to the voltage of the generator *G1*, and will not be affected by the resistance drop in the armature. The booster *B5* is excited from a two-field pilot exciter *ME5*, which has a pattern field *A* connected across the compoles of motor *M5*, and a balancing field *B* connected across the booster.

Speed control is effected by varying the generator voltage as shown in the simplified diagram (Fig. 7). A motor-driven master regulator *RM* is connected across the constant-

voltage busbars and the variable voltage thus derived serves as a reference voltage. The main generator field winding is excited from the output machine *ME*1 of the control exciter set. The pilot machine *PE*1 of this set is provided with two control field windings *A* and *D* (the stability windings of *PE*1 have been omitted from the diagram for clarity). Field *A* is energised from the reference voltage bars, and the field *D* which opposes *A*, from the armature of the main generator. Thus at any moment the main generator excitation is proportional to the difference between these windings, and the system is so designed that a small difference is sufficient to develop a considerable voltage change in the main generator voltage. The generator voltage thus reflects the reference voltage closely at all times, even when the reference voltage is changing rapidly, as when starting or stopping.

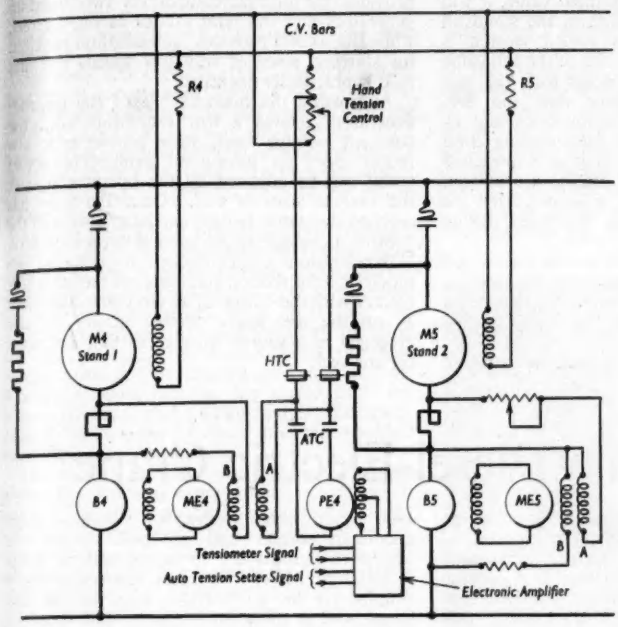


Fig. 6—Control Diagram for Stands

The motor *RP*, which drives the regulator *RM* controlling the reference voltage, is actuated by a small Ward-Leonard generator *G*5, an arrangement which allows ready alteration of the acceleration and deceleration times. By suitably grading the master regulator, the rate of rise of main generator voltage is made proportional to the speed of the regulator motor *RP*, which in turn is proportional to the voltage across its armature. This voltage thus provides a very convenient acceleration-compensating signal for the tension roll drives.

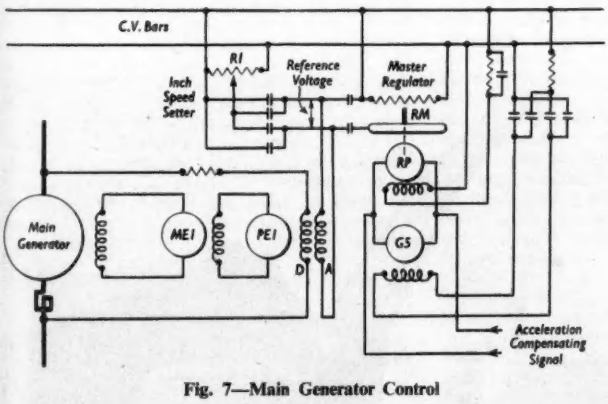


Fig. 7—Main Generator Control

The speed controls at the delivery cabinets are arranged so that "thread" and "run" speeds may be preselected there, the motion of the master regulator *RM* being automatically arrested at the required voltage. A hold button allows the motion of the regulator to be stopped at any intermediate point in either direction of travel. Depression of any stop button will cause the master regulator to run back to zero at high speed, rapidly reducing the mill speed by regenerative braking. Finally, at zero with the strip tension released the "suicide connections" are momentarily applied to the main generator and line contactors are opened.

Inching of main stands and tension rolls is effected from controllers on the cabinets, which close the forward or reverse inching contactors in the generator pilot exciter field *A*, thus applying a low excitation in the direction required. A small regulator *R*1 is provided so that the inch speed may be adjusted.

The control of Stand 1 is similar to that of Stand 2, with the addition of tension control of the strip between the stands. To provide this, the booster *B*4 (Fig. 6) is excited from a control exciter set, the pilot machine *PE*4 of which is arranged to amplify, in conjunction with an electronic amplifier, a signal received from the tensiometer roll. A changeover switch enables hand tension control to be obtained by the excitation of winding *A* of *ME*4. A second field winding *B* on exciter *ME*4 is connected across the compoles of the main motor and provides a component of booster excitation to compensate for resistance drop, as in the case of Stand 2. The booster thus performs the two functions of tension control and resistance drop compensation, and the range of excitation provided throughout is adequate to deal with the maximum specified difference in roll diameter.

Tension Rolls Control

Similar control arrangements have been adopted for both entry and delivery sections of the tension rolls; the simplified diagram for a single roll is shown in Fig. 8. The motor *M*2, which drives the tension roll, is separately excited from the constant-voltage line, the circuit being provided with the necessary trimming resistor *R*2. The motor has in its armature circuit a booster which is excited from a control exciter set, and the pilot machine *PE*2 of this set has three control windings *A*, *D* and *E*.

The current-excited winding *D* is connected across the motor compoles. The "tension-setting" winding *A* is connected to the constant-voltage line through a tension-setting regulator *RT*, which is ganged to a similar regulator for the associated tension roll. In the case of the top tension rolls this circuit also includes a potentiometer, which acts as a tension ratio adjuster which varies the voltage fed to the tension-setting field of the top rolls in relation to that fed to the tension-setting field of the bottom rolls. The tension-setting winding carries a current which is determined by the position of the tension-setting regulator, and which is balanced by the current signal in winding *D*. The excitation imposed on the booster is determined by the difference between these two excitations and the system is so designed that a small difference applies a powerful signal to the booster field. Thus the roll motor armature current is held closely to the value preselected by the tension-setting regulator, and so long as the excitation of this motor is contant, constant torque and tension will result. During acceleration or deceleration an additional adjustment of armature current is needed to maintain constant tension. Since the inertia of the rolls is constant and the acceleration of the mill approximately linear and proportional to the speed of the master regulator, a suitable signal is taken from the voltage across the master regulator pilot motor *RP*. This is applied to the exciter field winding *E* and brings about the desired increase or decrease in main armature current.

Uncoiler and Reel Control

A simplified schematic diagram of the reel equipment is shown in Fig. 9. The circuit of the uncoiler equipment is basically similar to that of the reel, though differing slightly in detail. Each motor is supplied from its own generator, which is controlled by a control exciter set. In both cases constant tension is produced under steady speed conditions by controlling the generator excitation to maintain the preselected armature current proportional to the desired strip tension, while the motor excitation is automatically varied to keep the E.M.F. induced in the motor armature constant for a constant strip speed as the coil builds up or unwinds, and proportional to the strip speed when the strip speed is varied. During acceleration and deceleration the reel motor torque or current is automatically increased or decreased by an appropriate amount to deal with the rate of change of speed, and also with the large and varying inertia of the coil and reel, so that the strip tension does not alter.

Referring to Fig. 9, it will be seen that pilot control exciter *PE*8 of the generator set is provided with two control field windings, of which *A* is excited by a signal derived from the saturable reactor *SR*.

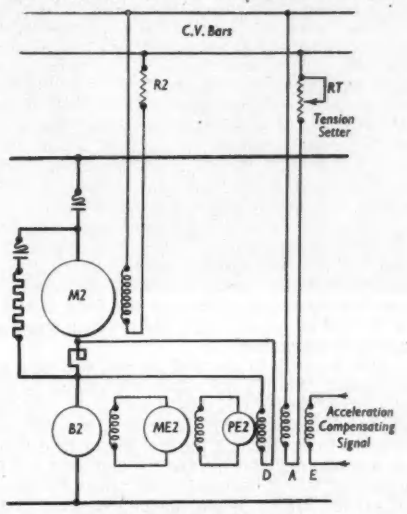


Fig. 8—Tension Roll Control

There are two input signals to the saturable reactor: the first is proportional to the main armature current, and the second is derived from the constant-voltage supply via tension-setting regulator *RT*. The second signal, which raises the generator voltage and current, is, under running conditions, almost cancelled by the first signal. The output signal which excites winding *A* of *PE*8 is proportional to the difference between the input signals, so that any departure from the armature current preselected by the tension setter brings about an immediate correction in excitation. To effect the necessary adjustment in the main armature current required during acceleration or deceleration a third signal is taken from the reference voltage bars and is applied to a differentiating transformer, the output of which is thus proportional to the rate of change of strip speed. This signal is passed to an electronic amplifier. At a suitable stage in the amplifier the signal is modulated according to the varying coil diameter, and hence inertia, of the coil and reel, and adjustment by means of contactors allows additional compensation for three stages of strip width. The signal from the

amplifier is thus proportional to the rate of change of speed and is suitably modified to take account of the varying inertia of the coil and reel. This signal is passed from the amplifier to a third control winding on the saturable reactor. This third control winding modifies the effect of the tension-setting winding and thus either increases or decreases the reel motor armature current by the appropriate amount.

The reel motor is furnished with two field windings, of which the first (*MF*1) is excited from the constant-voltage line via the trimming resistor *R*8. This winding is designed to provide the excitation corresponding to full speed with empty reel, i.e. the maximum service speed. The second winding *MF*2 is designed to cover the range between full and empty reel diameters, with a small allowance for regulating purposes. The winding *MF*2 is supplied from a control-exciter set, the pilot machine *PE*9 of which is excited in proportion to the reel build up.

The reel control-exciter set also includes two small generators *G*1, *G*2, so arranged that their E.M.F.s are proportional to the armature counter-E.M.F.s of Stand 2 driving motor *M*5, and the reel motor respectively. To accomplish this each of these generators has two field windings. One of these windings is connected across the armature of its associated mill motor and generates an E.M.F. proportional to the mill motor armature voltage; the second field winding is excited by the voltage across the motor compoles and generates an E.M.F. proportional to the voltage drop in the mill motor armature. Thus the total generator excitation gives in each case an E.M.F. proportional to the back E.M.F of the mill motor. The voltage of *G*1 is thus proportional to the back E.M.F. of the Stand 2 motor, whilst the voltage of *G*2 is proportional to the back E.M.F. of the reel motor.

These voltages are balanced against each other through the potentiometers *P*1 and *P*2 and the difference is applied to the field winding *A* of the reel motor pilot exciter *PE*9. This voltage difference is enough to alter the excitation of the reel motor field winding *MF*2 so that the total excitation produced by *MF*1 and *MF*2 generates a back E.M.F. in the reel motor armature which is at all times proportional to the back E.M.F. of the Stand 2 driving motor—that is, to strip speed. As the coil builds up and the reel diameter increases at constant strip speed, the speed of the reel motor progressively decreases and its excitation is automatically increased so that the relationship between the back E.M.F. of the reel motor armature and the strip speed is correctly maintained.

With no strip in the mill the reel will tend to overspeed. Should this occur, the voltage of *G*2 will exceed that of *G*1, thus reversing the polarity of the pilot exciter *PE*9. In order to prevent this reversal from reaching the reel motor field (and so accentuating the trouble by opposing *MF*1) a rectifier *RF*1 is included in the armature circuit of exciter *ME*9. When, under overspeed conditions, the polarity of *PE*9 is reversed, the field of the pilot exciter of the reel generator (winding *D* of *PE*8) will be energised via *RF*2, thus limiting the speed rise to approximately 20 per cent above thread speed. To cater for broken strip at speeds above the thread rate a relay across the motor field pilot exciter *PE*9 detects the reversal in voltage and quickly causes the whole mill to stop. Inching in either direction is effected by applying a small reversible field to the reel generator main exciter *ME*8 by means of inching controllers on the cabinets.

Since the reel generator will maintain the armature current at the prescribed value, it will automatically maintain tension in the standstill or stalled condition. This stalled tension is usually reduced to 15/40 per cent of the full value by inserting resistance in series with the reel tension setter. At the same time the field winding *MF*2 of the reel motor is excited by means of a special auxiliary field winding *B* on exciter *ME*9, since field winding *A* is unexcited because the reel and stand motors are at rest. This field winding *B*, which is excited from the constant-voltage busbars, is also used during inching of the reel motor.

At standstill stalled tension for the tension roll motors is obtained by transferring the tension-setting fields of their respective boosters from the running tension setter to the stalled tension setter.

The uncoiler equipment maintains constant tension whilst running at normal mill speeds, in the manner already described for the reel equipment. Some modifications, however, are necessary for threading conditions. Under normal starting conditions, with a full coil on the uncoiler, the motor field is at full strength. The motor field has two windings, one of which provides minimum excitation for the empty reel condition and the other variable excitation from the output machine of the exciter set. A rectifier is included in the latter circuit so that the second field can never be reversed to oppose the first. The main exciter also has two fields: the first provides the normal control via two build-up generators and the pilot exciter as on the reel, while the second provides the excitation required for starting, since at very low speeds the first field is practically unexcited.

At starting the main exciter of the uncoiler generator receives a low excitation from the constant voltage bars, thus providing a low motor speed for paying off strip. The actual speed can be adjusted by the operator to suit the various sizes of coil. Once the strip has reached the stands tension can be applied and the control is changed to the normal tension control.

Acceleration compensation is achieved by modifying the tension reference on the saturable reactor with the output of an electronic amplifier, as on the reel gear. Stalled tension is also arranged in a similar manner to that described for the reel.

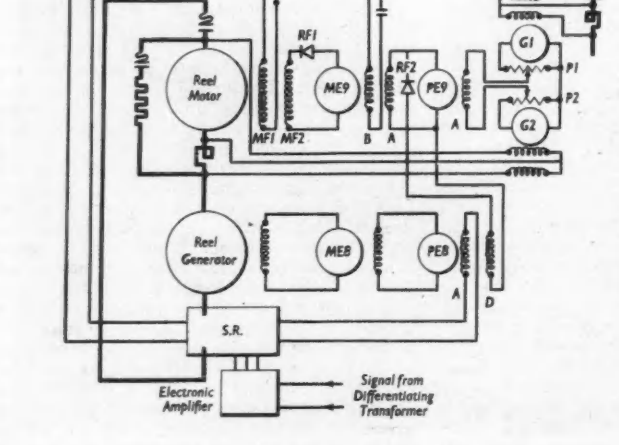


Fig. 9—Reel Equipment Control

A Mobile Diesel-Electric Crane

LAST week a demonstration was given at the works of Walker Brothers (Wigan), Ltd., of two arrangements of its recently introduced 6/8-ton diesel-electric mobile crane. One machine was arranged as a straightforward mobile crane, fitted with outriggers, as illustrated below, and the other was fitted with a grab. The cranes are designed to lift a load of 6 tons at a maximum range of 10ft without outriggers, and up to 8 tons with outriggers in use. A variety of jibs with centres from 13ft 3in to 35ft can be supplied according to requirements.

The crane is carried on a rigid six-wheeled chassis and all the vehicle and crane controls are arranged inside the driver's cab. When operating the crane the driver swings his seat round to face rearwards, and from this position he has a clear view of all movements with the controls easy to hand.

Power for the crane is supplied by a four-cylinder Gardner diesel engine rated at 75 b.h.p. at 1700 r.p.m., which is directly coupled to a 32kW, 335V generator. The engine speed is governed to 1700 r.p.m. for road travelling and 1300 r.p.m. when hoisting or slewing—i.e. at maximum torque—and at these speeds the respective outputs are 75 b.h.p. and 59 b.h.p. A 36 b.h.p., 335V, 1500 r.p.m. traction motor is coupled to the worm-driven axles of the rear bogie, and it gives an unladen road speed of 10 to 15 miles an hour.

The main chassis frame is of 10in deep flange channel, cross section braced, where necessary, and graded in section in order to avoid the effects of any sudden change in stress. Flitch plates and channel to a depth of 17in reinforce the bogie trunnion bracket. The makers point out that this chassis, due to its integral design with the crane base, derives certain stiffness from that structure, whilst the solid mounting of the bogie affords additional rigidity. The roller-mounted turntable is fitted on the chassis main side members forward of the bogie centre line. The upper half of this turntable carries the vertical "A" frame forming the pivotal point of the hoisting jib, and also attached to the upper

Mobile Crane

part of the turntable are the counterbalance weight and the hoisting, slewing and luffing gears.

Power is transmitted from the traction motor to the bogie through a needle roller bearing propeller shaft. In the bogie there are two worm-driven axles, each fitted with a differential gear. Rigid swing bars pivoted at their longitudinal centres and attached at each end to the axle beds, locate the two axles and allow longitudinal oscillation. Transverse movement, to a controlled degree, is permitted through the trunnion-mounted ends of the swing bars. A heavy tube straddles the main mounting brackets to each frame side member and completes a very rigid structure.

The load imposed on the frame mounting brackets is equally distributed to each axle, one axle can rise and the other fall without affecting the wheel load distribution; similarly since each swing bar is independently pivoted and anchored by spherical bearings, diagonally opposite wheels can rise without causing distortion to the vehicle frame.

Driving and braking torque reactions from each pair of wheels are absorbed by torque arms coupled to the bogie cross tube. The location of the arms—almost horizontal—makes it possible to increase the length, thus increasing the effective leverage whilst correspondingly reducing the end loading. The flexible joints on these torque arms are of bonded steel and rubber. The main bogie bearings are sealed from the ingress of water and foreign matter and comprise a 3in diameter hardened steel pin mounted on needle roller bearings.

The control unit for the 16½ h.p. hoisting motor is a reversing drum, spring return, switch situated on the right-hand side of the driver. Through a special gear this main hoisting motor can also be used for derricking, the arrangement being such that as the jib moves the bottom block remains horizontal. The control for the 3 b.h.p. slewing motor is similar to that used for the hoisting motor and is mounted on the left-hand side of the driver.

The vehicle is fitted with continuous flow hydraulic brakes operated by foot on all six wheels, and a hand brake operates on the four rear-driven wheels. The hand brake is specially designed to allow application of the shoes under hydraulic pressure and thus ensure an efficient and strong brake. The linkage is such that there is no snatch in the system, irrespective of the articulation of the axles and wheels.

The foot brake operates the hydraulic cylinders on the front axle which are adjacent to each brake drum, and there are therefore two independent systems operating the front and rear wheels.

Retractable hydraulic outriggers are used for loads of over 6 tons and up to 8 tons. These outriggers are operated by means of a hand pump and a distributor valve in the driver's cab, and when they are not in use fold up against the side of the vehicle. The outrigger arms are hinged at their centres and initial operation of the pump opens and extends them outwards. When the arms are fully extended the supply of hydraulic fluid is diverted through the distributor valve to actuate the long-stroke jacks at their extremities. Upon release of the hydraulic pressure the jacks retract and the outriggers fold back to their inoperative position.

Safety devices provided to prevent overloading, overwinding and overderricking automatically adjust themselves to the safe range for the conditions under which the crane is working, without requiring adjustment or calculation by the driver.

LIFEBOAT FOR EXHIBITION.—On Friday last an aluminium alloy lifeboat arrived at Wapping after completing a voyage across the North Sea from Oslo. The boat, which is 26ft in length, has been built in Norway by the Norsk Flyindustri, using aluminium alloy material supplied by Birmabright, Ltd., and is powered by a Petter engine. From Wapping the lifeboat will be transported to Olympia, where it will be displayed at the Engineering and Marine Exhibition before being delivered to the Barrow-in-Furness yard of Vickers-Armstrongs, Ltd., where the ship for which it is intended, an oil tanker for the British Tanker Company, Ltd., is being built.

Reconstruction of an Engineering Works

WHEN the works of Sir W. H. Bailey and Co., Ltd., at Patricroft, Manchester, were completely destroyed by enemy action in 1940 the business was transferred to an old ironfoundry nearby. This foundry had been acquired by the company some years before and although it was still in production it was in a very bad state of repair. As a result of strenuous efforts a certain amount of plant was recovered from the bombed site, and production on a reasonable scale was resumed in a few months in premises which were far from satisfactory. Before the end of the war, and with production steadily increasing, work had begun on the conversion of the old buildings to suit them for modern needs, and on the construction of new shops. In the course of this work half the offices, a brassfoundry, a pattern shop, and an instrument room were built, and the original moulding shop was re-roofed and enlarged to form the main machine shop.

In the course of a recent visit to the firm we were informed that a further stage in the work of rebuilding was well in hand. With the completion of this work the old cupola house and melting shop of the original foundry will have been rebuilt to provide a large new materials stores and a finished products stores. It should be mentioned here that up to the time the works was destroyed the firm manufactured many kinds of valves, pumps and instruments. When reconstruction of the works was being planned in 1946 the policy of the firm was changed and it was decided to specialise in certain lines and cut down the range of products. A large number of unimportant items was dropped, and in a further step made in 1949 the manufacture was ceased of the boiler mountings, which accounted for a large section of the non-ferrous products.

Now the works has been organised for the manufacture of six main groups of equipment, including pressure reducing valves and regulators with their ancillary equipment; "Quality First" sluice, parallel, slide, globe, stop and other valves, particularly of large low and medium-pressure design; high-pressure pumps; high-capacity high-vacuum pumps; pressure and vacuum gauge testers; and turnstiles.

The machine shop, built over the area originally occupied by the moulding section of the old foundry, is equipped with a selection of light machine tools suited to individual special or batch production of components. It adjoins, and one end is open to, a new building some 140ft long by 90ft wide, and which is considerably higher. This new shop, part of which can be seen in the illustration on this page, is equipped with a group of heavy machine tools, and the large components coming off these machines have only to be moved a short distance by an overhead travelling crane to the main assembly area in the centre of the shop. Bays on each side of the shop are used for small component assembly and building up parts for fitting to the larger units in the main assembly section. A test section laid down in one corner of this shop is equipped with tanks, pumps, &c., of varying capacity for carrying out hydraulic pressure and other tests on units before they pass to the despatch department.

The upper storey of a very old mill building which originally stood at one side of the machine shop was removed during the war, as it was not safe. This building now houses a light machine shop, pattern storage space, and a modern canteen. The instrument department built on during the war now contains the drawing-office and a light assembly shop.

On the other side of the new heavy shop a well-equipped modern ironfoundry has been laid down in a new building over 100ft long by 50ft wide. This foundry has a productive capacity of some 15 tons of iron castings a week. Non-ferrous casting is carried out in a separate small foundry having three furnaces with a total capacity of some 5½ tons a week. This foundry is a self-contained unit and, with a pattern shop which adjoins one end is arranged in one of the new buildings on the original site.

During the work of converting the site on which the original ironfoundry and some of the old mill buildings were set up more than a century ago, many compromises had to be made owing to plant, material and labour shortages. Despite the difficulties involved, however, production was steadily increased and development work was continued.

Main Erection Shop

Guntershausen Bridge, Germany

The railway bridge at Guntershausen, over the River Fulda, was built nearly a century ago. It consisted of thirteen arches, seven of which (the central part) were destroyed in 1945. Various designs were studied by German railway engineers for reconstructing the structure, and it was finally decided to keep all sound parts of the old bridge and replace the damaged spans by a concrete arch, 328ft long. The new bridge is thus about 400ft long; it consists of two similar parallel structures, separated by a joint 3in wide, each one carrying a single track. In this way traffic interruption during the work was greatly reduced. The arches are of box-shaped cross section and have a 35ft rise. The centering was used twice, being moved over after completion of the first single-line arch. The reconstruction required about 850 cubic yards of concrete and 82 tons of reinforcing steel.

Metallurgical Topics

Surface Defects in Hot-Worked Mild Steel

In order to investigate the cause of fine surface defects which were produced during hot-working of mild steels in the manufacture of tubes, H. Buchholtz and R. Pusch[1] carried out rolling and scaling tests in various furnace atmospheres on steels from several steelworks and of different date of manufacture. Both killed and rimming steels were investigated. The killed steels contained carbon 0·08 per cent to 0·16 per cent (with one exception, 0·36 per cent), the rimming steels 0·04 per cent to 0·10 per cent. They all contained some residual elements, usually nickel and copper, sometimes chromium. A series of high-frequency furnace melts was also made. These were 0·1 per cent carbon steels, purposely containing copper or nickel or equal amounts of both up to a total of about 0·35 per cent. Metallographic and spectrographic examination of the surface of the annealed steels showed that with long times of exposure to town's gas burning with a deficiency of air and with increasing temperature, especially above 1200 deg. Cent., there was a progressive enrichment of copper and nickel in the surface layers of the steel to a depth of about 0·1mm immediately under the scale. In many samples there was also an enrichment of sulphur in the form of iron sulphide and probably also of copper and nickel sulphides. Along with this surface enrichment there was a preferred oxidation of the grain boundaries. These two effects make the surface of the steel hot-short when subjected to multi-axial stress as in hot pressing, giving surface roughness due to fine cracks to a depth of about 0·1mm, equal to the depth of the enriched zone and the oxide migration. The satisfactory temperature range for hot working was displaced and narrowed by the presence of copper and nickel. Of the killed steels the most susceptible to surface cracking in an impact cupping test on plates 7mm thick was the steel containing carbon 0·15 per cent, chromium 0·15 per cent, copper 0·13 per cent, and nickel 0·18 per cent, and the least susceptible that with carbon 0·11 per cent, chromium nil, copper 0·03 per cent, and nickel 0·01 per cent. The high-frequency melts, similarly tested after being heated in waste gas containing 3 per cent of hydrogen and 10 per cent of water vapour, showed very few grain boundary defects until copper and nickel exceeded 0·15 per cent and the annealing temperature 1200 deg. Cent., but with a temperature of 1300 deg. Cent. or a copper and nickel content, either alone or together, of 0·3 per cent, the scaling and surface cracking were greatly increased. Pure steels, heated at 1300 deg. Cent. in waste gas with high water-vapour content are often susceptible to these defects.

The authors conclude that hot working temperatures above 1200 deg. Cent. are of questionable value for soft unalloyed steels. Prolonged heating (for more than ½ hour) at such a temperature should be avoided. In preheating for difficult hot working processes coal gas with either lack of air or too high an excess of air must be avoided. A weakly oxidising gas-air mixture with 1 per cent or 2 per cent of oxygen in the waste gases lessens the formation of adherent scale and grain boundary oxidation, and therewith the hot shortness of the steel surface. Works observations show that hot shortness of the surface is not produced by heating in carbon monoxide, hence it may be assumed that hydrogen and water vapour are essential for grain boundary oxidation. Melts with a higher total content of copper and nickel than 0·15 per cent should be avoided for difficult hot working operations, though so many factors are involved that no limits can be rigidly laid down. Safeguarding against these fine surface defects may have to be exercised at all stages from the blast-furnace charge, steel works scrap, conditions of reheating the ingot and half-finished products up to the last stage of hot work.

Many years ago, F. Nehl[2] showed that on heating steels containing 0·8 per cent to 1·0 per cent of copper for hot working, metallic copper sometimes separated below the outer layer of scale and penetrated the grain boundaries, causing hot shortness if stress was applied at temperatures above the melting point of copper. The temperature at which hot shortness appeared was raised by the addition of nickel, which strengthened and raised the melting point of the copper. This was rather a different phenomenon from that observed by Buchholtz and Pusch, in which the nature of the furnace atmosphere played an important part. Their recent investigation may rather be regarded as an extension of the work of Pfeil[3], who demonstrated the concentration of nickel in the innermost layer of scale on a nickel-bearing steel and the accompanying intercrystalline oxidation, and of that of Preece[4], who investigated the effect of furnace atmospheres on intercrystalline penetration of an oxide-sulphide complex.

[1] *Stahl und Eisen*, February 12, 1953, page 204.
[2] *Stahl und Eisen*, July 27, 1933, page 773.
[3] *Journal of the Iron and Steel Inst.*,1929 (I), page 501.
[4] *Journal of the Iron and Steel Inst.*, 1943 (I), page 43.

Basic Bessemer and Open-Hearth Steels

It has long been recognised that steel made by the basic Bessemer process differs in important respects from steel of very similar composition made in the open-hearth furnace. Some of the characteristics of the Bessemer steels constitute advantages for certain purposes ; for example, it has superior machinability and welding properties. Bessemer steel has a higher yield point than open-hearth steel of equivalent composition ; and an equal degree of cold working gives rise to a product of greater tensile strength in Bessemer steel than in open-hearth steel. On the other hand, the greater tendency of Bessemer steels to work-harden may lead to excessive hardness with accompanying brittleness when manufacturing conditions are severe.

The principal difference between the two types of steel is due to chemical composition, particularly the nitrogen content, and, to a lesser degree, the phosphorus content. Before 1939 work in this country was directed to the improvement of basic Bessemer steel, and an account of this development was written by Dr. H. A. Dickie.* In Germany a wider application of basic Bessemer steel was rendered imperative by a deficiency in the open-hearth capacity, and this compelled attention to be directed to the production of a steel of improved quality, examples of which existed in the basic Bessemer steels of Luxemburg and Lorraine.

A review of "The Behaviour of Rimming Basic Bessemer Steels and of Open-Hearth Steels During the Tensile and Notched-Bar Impact Test" has been published by O. Hengstenberg and W. Jäniche.† The study on which the review is based was carried out in the years 1943–44. It had as its object the comparison of the properties of the ordinary and the improved basic Bessemer steels with those of open-hearth steels of equal tensile strength in the rolled and in the strain-aged condition. Three series of observations were made. In the first series there were 153 basic Bessemer steels and 22 open-hearth steels of similar composition. They were placed in six classes according to their nitrogen content. The mean composition of each class with respect to carbon, phosphorus and nitrogen was as follows :—

	Number of specimens	Carbon, per cent	Phosphorus, per cent	Nitrogen, per cent
Bessemer ...	23	0·05	0·041	0·010
	89	0·05	0·060	0·014
	33	0·07	0·068	0·018
	6	0·07	0·071	0·023
Open-hearth...	2	0·06	0·067	0·027
	22	0·13	0·030	0·005

The silicon was about 0·02 per cent, manganese about 0·36 per cent and sulphur about 0·04 per cent.

The tensile strength of the basic Bessemer steels increased with increasing nitrogen content (and the accompanying phosphorus). The improved basic Bessemer steel (the first of these classes) had a lower tensile strength than the open-hearth steels on account of its lower carbon content. Yield points were higher the greater the tensile strength ; but the yield points of the open-hearth steels were lower than those of the Bessemer steels of the same tensile strength. After 10 per cent deformation by cold work and thirty days' ageing at room temperature the yield points were raised by amounts which increased with increasing tensile strength of the original material, but on the basis of equal tensile strength no difference was observed between the Bessemer and the open-hearth steels. After 340 days at room temperature or after heating for half an hour at 250 deg. Cent. the yield point was raised in a similar way with increasing tensile strength of the specimen in the rolled condition. The rise in yield point after artificial ageing was rather greater in the open-hearth steels than in the Bessemer steels. Elongation of the rolled material was greater in the open-hearth steels than in the Bessemer steels of the same tensile strength, but the fall in elongation due to cold working and ageing was also greater. Reduction of area of the open-hearth steels fell more rapidly with increase of tensile strength than that of the Bessemer steels, but the loss of reduction of area after cold working and ageing was somewhat lower for the open-hearth steels, so that both types in the aged condition at the same tensile strength showed similar reductions of area. The "strengthening index" of these steels was determined as a measure of their hardening under strain. This was defined as increase in true stress divided by increase in log F_o/F, where F_o is the initial cross section and F the actual cross section after loading. For a given tensile strength of the rolled material, the "strengthening index" was decidedly lower for the open-hearth than for any of the basic Bessemer steels. Notched-bar impact tests‡ were carried out at 20, 60, 100 and 200 deg. Cent. on the steels cold worked 10 per cent and heated for half an hour at 250 deg. Cent. For a given tensile strength the open-hearth steels gave the best impact value at all these temperatures. The basic Bessemer steels showed widely scattered results at 60 deg. and 20 deg. Cent. At −20 deg. Cent. they gave decidedly low values except the improved basic Bessemer (first group), which still showed scatter but sometimes, in the low-tensile material, approached the values given by the open-hearth steels. The transition temperature from tough to brittle fracture was unmistakably higher for the cold-worked and annealed basic Bessemer steel than for the open-hearth steel in the same condition.

The steels of series II consisted of five groups, viz. :—

	Number of specimens	Carbon, per cent	Phosphorus, per cent	Nitrogen, per cent
Bessemer ...	3	0·07	0·037	0·005
	7	0·07	0·047	0·010
	5	0·06	0·048	0·013
	3	0·10	0·079	0·018
Open-hearth...	7	0·11	0·025	0·005

The steels were cold worked 5 per cent, 10 per cent, 15 per cent, and 20 per cent and tested at temperatures between 100 deg. Cent. and −20 deg. Cent. The loss in impact value was greater the higher the nitrogen and phosphorus content. The open-hearth steels showed the smallest loss. The difference between the groups was most evident at 20 deg. Cent. and all groups showed the same relative behaviour at −20 deg. Cent. (Fig. 1). Fig. 2 shows the percentage loss of impact value by cold working, the further loss on heating for half an hour at 250 deg. Cent. and the final impact figure as a percentage of its original value at 20 deg. Cent.

In series III the effect of form of test piece and testing temperature was examined by testing

* *Journal of the Iron and Steel Institute*, August, 1948, page 360.
† *Stahl und Eisen*, June 18, 1953, page 828.

‡ DVM specimen, section 10×10mm, notch 2mm diameter 3mm deep.

seven groups of steels, comprising twelve improved and sixty-two ordinary basic Bessemer steels, and fifteen basic open-hearth steels. Tests were made on the cold-worked material annealed at 250 deg. Cent. With a notch of 4mm radius the open-hearth steels and the low-nitrogen low-phosphorus Bessemer steels, on the whole, showed no difference. With a sharper notch the basic Bessemer steels showed considerable scatter; and with a still sharper notch the cold-worked and aged open-hearth steels could be clearly distinguished from all the basic Bessemer steels by their higher impact value at 100 deg. Cent. Thus, different experimental conditions

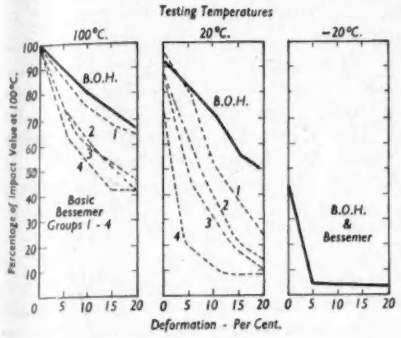
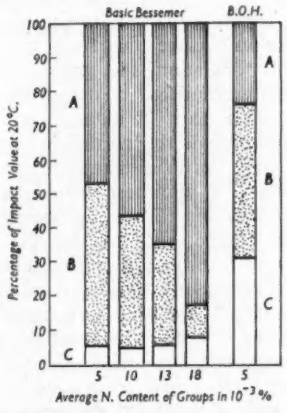


Fig. 1—Influence of Cold Working on the Impact Value of Normalised Rimming Basic Bessemer and Open-Hearth Steels (Hengstenberg and Jäniche)

in the notched-bar impact test had a decided influence on the comparative data. As the authors point out, the standard of valuation must be adjusted to the particular demands which will be made on the steel in working and in use.

Effect of Chemical Composition

In 1910, C. E. Stromeyer directed attention to the importance of chemical composition in producing embrittlement and concluded that the nitrogen content by weight was five times more potent than the phosphorus content. This



A.—Loss of impact value due to 10 per cent cold reduction.
B.—Further loss due to heating for half an hour at 250 deg. Cent.
C.—Final impact figure after cold work and artificial ageing.

Fig. 2—Influence of Cold Working and Ageing on the Impact Value of Normalised Rimming Basic Bessemer and Open-Hearth Steels (Hengstenberg and Jäniche)

relative influence of nitrogen and phosphorus has recently been questioned. In a paper by H. Knüppel and K. Meyer,§ on the "Correlation Between Chemical Composition and Notched-Bar Impact Value After Ageing of Rimmed Steels," results are given of notched-bar impact tests at temperatures from 20 deg. to 180 deg. Cent. on rimming steels containing carbon 0·02–0·09 per cent, manganese 0·18–0·65 per cent, phosphorus 0·015–0·115 per cent, sulphur 0·008–0·042 per cent, nitrogen 0·003–0·016 per cent, and oxygen 0·007–0·055 per cent. Specimens, 10mm by 10mm, with a notch 2mm diameter and 3mm deep, were prepared from 10 open-hearth steels, 190 ordinary basic Bessemer, 107 basic Bessemer blown with oxygen, and 10 basic Bessemer steels blown with a mixture of oxygen and carbon dioxide. Other forms of test piece were also employed. It was found that phosphorus, nitrogen and oxygen had the greatest influence on the strain-age-embrittlement of the steels. Their relative potency is given as 1 : 3·3 : 0·75. Sulphur was thought to have an effect, but as the sulphur content tended to fluctuate with phosphorus and nitrogen its influence was masked by that of these elements. Manganese hardly exerted any effect. The influence of carbon showed only in the slightly higher carbon content of the open-hearth steels. All the steels after being strained 10 per cent and heated for half an hour at 250 deg. Cent. had a low impact figure at 20 deg. Cent. Knüppel and Meyer suggest taking as a figure of merit or criterion of toughness the area beneath the impact value/temperature curve between the limits 20 deg. and 180 deg. Cent., expressed as kilogram-metres per square centimetre multiplied by degrees Centigrade. Its value appeared to vary from about 400 for high-nitrogen high-phosphorus basic Bessemer steels to about 3000 for basic open-hearth or low-nitrogen low-phosphorus basic Bessemer steels.

Methods of control of nitrogen and phosphorus content were not dealt with in Hengstenberg and Jäniche's paper; but it was pointed out that, apart from the overriding influence of nitrogen and phosphorus, other factors may help to account for the difference between the open-hearth steels and the improved basic Bessemer steels, and also between different basic Bessemer steels, one of these factors being grain size. Judged by the Stromeyer index, 1000 (P+5N), the improved basic Bessemer steels included in this survey did not approach the quality of some of those described by Dr. Dickie, in whose paper can be found examples of nearly all the effects described in Hengstenberg and Jäniche's report, which, however, constitutes a valuable comprehensive review of some of the properties of the two types of steel.

§ *Stahl und Eisen*, March 26, 1953, page 401.

Effect of Rare Earth Elements on Stainless Steels

Much interest has been shown in recent years in the effect of the rare-earth elements on steels in general. One of the first to write on the subject was C. B. Post (chief metallurgist of the Carpenter Steel Company), who dealt with their influence on the hot working of austenitic stainless steels,[1] and, in conjunction with H. O. Beaver, he has now taken the matter further in a paper to the American Iron and Steel Institute.[2] These writers confirm that hot-short austenitic stainless steels may be transformed into ductile alloys by the addition of mischmetall giving a cerium plus lanthanum content of at least 0·02 per cent. Smaller mischmetall additions to low-alloy austenitic stainless steels (the 18 : 8 type) improve the hot workability of the steels which are inherently ductile and improve the surface finish of forgings. Thus, cerium and lanthanum not only counteract hot-shortness, but they increase fluidity and improve ingot structure simultaneously.

Products consisting largely of rare-earth oxides have appeared on the market for use as ladle additions. The authors' experience with these was that by their use the hot-working properties of the inherently ductile austenitic steels could be improved at smaller cost than by the use of mischmetall; but that they did not lead to any improvement in the hot workability of the hot-short or difficultly workable grades of austenitic steels. In these, residual cerium and lanthanum contents of 0·02 to 0·25 per cent are beneficial; but, after treatment with oxides, a very small amount of cerium and lanthanum, if any, passes into the metal. Cerium fluoride was found to have beneficial effects on type 321 steel (carbon 0·10 maximum, chromium 17–20, nickel 7–10 per cent with titanium, minimum, four times the carbon content). No cerium passed into the metal, but 2 oz of cerium fluoride per 1000 lb gave a better billet yield. The cerium fluoride liquefies immediately, gives a fluxing action and produces a cleaner titanium-bearing steel.

It has been claimed, in connection with Lan-cer-amp additions, that 2 lb per ton added to a basic electric steel will reduce the sulphur content to half.[3] This is borne out by Post and Beaver's experience, though with larger additions of mischmetall. The record reproduced below illustrates the effect of mischmetall additions on the hot-working properties and also on the sulphur content in an experiment in which sulphur additions were purposely made to a steel containing carbon 0·046, manganese 0·89, silicon 1·12, chromium 20·23, nickel 28·83, copper 3·69 and molybdenum 2·50 per cent.

Additions	Per cent sulphur	Per cent rare-earth elements	Remarks, forgeability
As melted	0·007	—	Poor, torn
12 lb mischmetall per ton	0·005	0·17	Good, no tears
0·01 per cent S ...	0·011	0·10	Good, no tears
0·02 per cent S ...	0·024	0·04	Hot-short, tears
0·03 per cent S ...	0·043	0·01	Hot-short, badly torn
12 lb mischmetall per ton	0·021	0·09	Good, no tears

References

[1] The Engineer, December 28, 1951, page 831.
[2] *Iron Age*, June 4, 1953, page 148.
[3] The Engineer, September 26, 1952, page 417.

Rapid Tool-Life Testing

The conventional laboratory method of tool-life testing usually consists of machining with a cutting tool, either until complete failure occurs or to a predetermined amount of flank wear as measured with a microscope. In either case the test requires a great deal of time and material and involves considerable cost in order to obtain a relatively small amount of information. Attempts to accelerate the test, for example, by employing abnormally high cutting speeds, usually yield results which do not agree with practice. A method of evaluating tool life more rapidly with a smaller expenditure of material is desirable. Such a method cannot be based on tool failure, but it might be based on rate of tool wear if this could be measured over a sufficiently short time. A paper by M. E. Merchant, H. Ernst and E. J. Krabacher* describes a method of measurement of cutting-tool life in which radioactive isotopes are used as tracers to measure the "instantaneous" rate of tool wear at any time during the life of the tool. The method consists of machining with a tool which has been rendered radioactive by neutron irradiation in a nuclear reactor, collecting the resulting chips and measuring their radioactivity caused by the particles abraded from the tool during the few seconds of cutting.

The isotopes formed in high-speed tool steel were Cr 51, W 185 and Co 60; in cobalt-bonded tungsten and titanium carbides W 185 and Co 60; in cobalt-bonded tungsten, tantalum and titanium carbides W 185, Ta 183 and Co 60. The cutting tools used for the tests were small tool tips about $\frac{1}{16}$ in square by $\frac{1}{32}$ in thick. They were ground to shape and marked for identification before being irradiated. Each individual test required not more than thirty seconds cutting time. All handling was done by remote control. The laboratory was constructed and equipped in accordance with suggested practice for radio-isotope work. All cutting tests were made in a completely enclosed chamber. The resulting chips, and when necessary the cutting fluid, were collected and removed through the cutting-chamber door. They were then placed in a Marinelli beaker, a type which contains a central cylinder into which a Geiger tube counter may be inserted without coming in contact with the chips. Counts per minute per gramme of chips was found to be a direct measure of rate of tool wear. Cumulative radioactivity as measured in this way was correlated with wear measurements made with a microscope. Reproducibility of results and the ability of the method to show relatively small differences in tool life were substantiated in a number of experiments.

The method is still in an early experimental stage of development. It needs special technique and equipment which is expensive to install, and the co-operation of an atomic energy establishment is required in the production of the isotopes. The method, however, appears to hold out promise of giving results which are just as reliable as those given by the more protracted conventional methods of testing tool life.

* "Radioactive Cutting Tools for Rapid Tool-Life Testing," *Trans. Am. Soc. Mech. Engrs.*, May, 1953, page 549.

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ENGINEERS IN CORNWALL

Last spring we paid a visit to Cornwall, having as guide Mr. Tregoning Hooper, Hon. Secretary of the Cornish Engines Preservation Society. To most people Cornwall is a somewhat distant county notable for the rugged grandeur of its coastline, the charm of its fishing villages, yachting in the Helston inlet and at Falmouth and the romanticism of Lands End. But to engineers, and particularly those who have made any study of engineering history, it is a much more exciting place. Heaven knows for how many centuries tin and copper have been mined in Cornwall ! Certainly there were tin workings there in early Roman days and probably for centuries before. But true engineering interest did not begin until the eighteenth century, when Newcomen engines began to be used for pumping out the mines. Later James Watt found a profitable business there converting those engines to working with a separate condenser and installing many new engines. Later still, Cornish engineers, turning, in defiance of Watt's timidity, to the use of steam at then relatively high pressures, immensely improved the economy of the engines. The consequence is that to this day the inland scenery of Cornwall is studded with literally hundreds of engine houses. All are closely similar in design as dictated by the shape of the beam engines that they housed, tall in relation to their width with an opening near the top through which the beam projected. Nor is that the only consequence. The slow-moving Cornish engine had such longevity, cost so little to maintain and proved so economical in use that even between the wars electric winders and pumps were hard put to it to justify their cost, and to-day two Cornish beam engines are still performing useful service even though their eventual replacement can be foreseen as very soon inevitable. It is an immensely exciting experience, for example, to visit the South Crofty mine and see, not as a museum curiosity but as a piece of ordinary working equipment, the 80in, 10ft stroke beam engine operating there.

In this issue we print an article by Mr. Tregoning Hooper extolling the achievements of Cornish engineers. It does not praise them more highly than they deserve. For early in the nineteenth century Cornish firms led the world in steam engine design. There, to mention only the most famous of a constellation of famous Cornishmen, Trevithick, the originator of the Cornish boiler, of the high-pressure engine exhausting to atmosphere and of the locomotive, was born and gained experience. There the high-pressure, expansive, condensing engine was so rapidly developed that engineers elsewhere in the country disbelieved the claims of Cornishmen that the engines made by a group of famous firms in that county could perform duties in the neighbourhood of 100 million foot pounds per bushel of coal consumed ; and could not be convinced until engineers from elsewhere, including Rennie, Galloway and Farey, had performed independent tests. The famous Fowey Consols 80in engine, built in 1835, attained a duty of 125,095,713 foot-pounds per bushel of coal, equivalent to 1·48 lb of coal per horsepower-hour. Cornwall, indeed, was the nursery of the high-pressure, expansive condensing steam engine. It was when that point came to be more generally recognised that the Cornish Engines Preservation Society came into being. Its objects are to acquire and preserve existing examples of Cornish engines, to preserve certain engine houses that are noteworthy for the famous engines they contained or, like those at Botallack, in crags under the cliffs of Cornwall's Atlantic shore, for the romanticism of their situation ; and to prevent wilful destruction of the hundreds of other houses that add character to Cornwall's inland scenery some of which have been treated by vandals as quarries and others of which have even been blown up in the course of military exercises. That Society after achieving some of its objects went into "cold storage" during the war. But early next month it intends energetically to renew its activities. On September 12th, as announced in our issue of July 31st, there is to be an interesting ceremony at Camborne. Through the generosity of Lord Falmouth the Society is to acquire the 22in Rostowrack engine formerly used for combined pumping and winding in one of his Lordship's china clay pits ; and, on the initiative of Mr. Treve Holman, a place has been found to re-erect it in working order, operated by compressed air, in the Camborne Engineering Museum created by Holman Brothers, Ltd. On the date named the engine will be formally presented to the Society by Lord Falmouth. It will make an interesting addition to the Society's other properties, which include a 90in pumping engine still at work on East Pool mine ; a 30in rotative winding engine on the same mine ; and a 24in winder on the Levant mine, out on the far Atlantic coast of Cornwall.

In the past the Society has much benefited from the generosity of others in acquiring property, besides deriving finance from the subscriptions of its members. But in acquiring or preserving further property it cannot too much depend upon such generosity in the future. Financially it has two problems to face, which, though but facets of a single whole, can be seen to be distinct. In acquiring properties and even more in making arrangements for the satisfactory preservation of properties heavy expenses will need to be met. For example, the winding engine at Levant is situated in an out-of-the-way place far from any large centre of population, and grave difficulties have been encountered in preventing unauthorised access to it let alone in preventing its decay through the corrosive quality of salt sea air. Yet to dismantle it, remove it and re-erect it elsewhere would prove a costly undertaking. Thus the Society needs capital to expend, once and for all, for the acquirement of property, putting it in order and, when necessary, housing it suitably, as the Rostowrack engine is now housed. In addition, the other facet of the whole, it needs a regular annual income with which to care for and maintain its properties in good condition and in such a way that engineers visiting Cornwall shall have access to them. For our part, having recently visited Cornwall, seen what there is to preserve and heard what the Society hopes to do, we heartily commend to engineering firms and to engineers in general any appeal that the Society may soon make to them. We recommend, too, to all engineers the idea of spending a few days as soon as possible in Cornwall. For perhaps within a twelvemonth, perhaps sooner, the last two Cornish engines, still at this moment at work, will have been superseded by electric machinery. The sands are running out. If, for example, the South Crofty 80in engine is to be seen at work, as we saw it last spring, a visit to it must not be long delayed. All who do visit it and the many other objects of engineering interest in Cornwall will, we are convinced, wish to help the Society to achieve its objects.

GUIDED MISSILES

An iron curtain which deprives us of information of British progress in developing weapons and military equipment is no less to be deprecated than the iron curtain now hiding the East from the West. Details of design and manufacture are necessarily a close secret, but the British taxpayer is entitled to be told what our potential enemies already know. There is, indeed, no sound reason why Mr. Duncan Sandys' recent statement on guided missiles should not have been made a year ago. At that time, as our readers are aware, we wrote, in an article on rocket development, that anti-aircraft guided rockets were in an advanced stage of development and could destroy aircraft flying at above 60,000ft. Our authority was the Chief of Staff of the United States Army and it could equally well have been the British Minister of Supply. For in the design and development of guided missiles, atomic weapons and new types of machinery and equipment, British scientists and technicians have nothing to learn from their United States colleagues.

It is encouraging, even at this late stage, to have official news of our own progress in developing guided missiles, particularly in view of the sensational reports of Russia's capacity to produce thousands of guided rockets every year. It is not, however, so comforting as it appears. The Minister emphasised that the piloted bomber has now an almost impossible task to outmanœuvre the anti-aircraft guided missile. But the piloted bomber seems itself in the process of being displaced as a carrier of explosives by the long-distance guided rocket, even though much investigation will still be required before the rocket can be regarded as a reliable and efficient bombardment missile. Already, however, the rocket is no longer the inaccurate missile which we knew during the war as the "V-2." It is, in fact, exactly the same in principle as the anti-aircraft guided missile and, equally, can guide itself throughout its trajectory. Moreover, with the application of atomic explosive for use in conventional weapons, it has become a more worthwhile missile. The warhead of a missile of the size of the German "V-2" would, indeed, now cause vastly greater destruction than the 10-ton "block-buster" carried by giant aircraft. In this country attention has been largely concentrated on the development of the anti-aircraft missile, but in the United States the large, long-distance guided rocket has been the subject of much investigation and research. Two years ago a surface-to-surface rocket underwent a successful test in that country. It weighed 5½ tons, had a total length of 48ft and attained an altitude of 135 miles and a speed of 4100 miles an hour. One of the main problems still requiring solution is to find the most suitable liquid fuel propellant for these long-range missiles. Various compounds have been tried—ammonia, hydrogen and ether as fuel, and hydrogen peroxide and pure liquid oxygen as oxidisers—but each has its disadvantages, and a really satisfactory propellant has yet to be found. It is important to note these fuel difficulties since it is probable that the fuel question will for many years to come limit the range of these missiles to some 500 to 700 miles. Ranges up to 2500 miles which have been suggested appear fantastic unless the missile is to be prohibitively expensive and made so large that it becomes itself an easy target for the anti-aircraft guided missile.

The characteristics of the long-distance rocket suggest that it may prove a missile best suited for seapower, for its relatively short range, compared with the range of a long-distance piloted bomber, necessitates launching it from positions off an enemy's coast. The large guided rocket may, in fact, mean the reappearance of the battleship with a dual armament of launching platforms and guns—the size of the gun depending on the armament of potentially hostile surface vessels which may be able and willing to dispute the control of the sea routes. The need for the aircraft carrier will still remain, to provide both fighter protection for ships at sea and air support in combined operations pending the establishment of bases ashore for land-based fighters. From the standpoint of defence, essential requirements are a first-rate radar warning system to give ample notice of the approach of large guided rockets and the production of small guided missiles capable of very high speeds and able to bring them down in the sea or on areas where they will do relatively little damage. As we are given no information upon the point, we can but presume from the obvious need that the rocket research programme includes work upon the development of anti-rocket missiles.

Obituary

S. PARKER SMITH, C.B.E.

We have learned with regret of the death of Professor Stanley Parker Smith, of "Ardshiel," Pitlochry, which occurred on Friday last, August 21st, at the Perth Royal Infirmary, following a severe operation. Dr. Parker Smith, who was in his seventieth year, had occupied prominent positions in the profession of electrical engineering. For many years he was Professor of Electrical Engineering at the Royal Technical College, Glasgow, and latterly had taken responsibility for the organisation of the staff college established by the North of Scotland Hydro-Electric Board in 1948.

Stanley Parker Smith was born at Grantham on February 23, 1884, and was educated at Grantham Grammar School, Sedgebrook School, Armstrong College at Newcastle upon Tyne, and at the Technische Hochschule, Carlsruhe. In 1905, he was the recipient of an 1851 Royal Exhibition Research Scholarship, and two years later took up an appointment with the Siemens Company, at Stafford, as an assistant designer. Subsequently, for three years from 1909 to 1912, Parker Smith was chief designer for the General Electric Company, Ltd. In the latter year, he began his teaching career by becoming a lecturer and assistant professor in electrical engineering at the City and Guilds (Engineering) College. During the first world war he acted as a consultant to Vickers, Ltd., in Sheffield, and in 1923 was appointed to the Chair of Electrical Engineering at the Royal Technical College, Glasgow. Shortly after his retirement from that Chair, Dr. Parker Smith was invited, by the North of Scotland Hydro-Electric Board, in 1948, to undertake the organisation of the staff college which it set up at Pitlochry.

Throughout his long and active career, Dr. Parker Smith made many contributions to technical literature, among which there were numerous papers to the learned societies. He was a member of the Institution of Electrical Engineers, served as chairman of its Scottish Centre from 1939 to 1941, and was elected a vice-president in 1942. He was also an associate member of the Institution of Civil Engineers. Dr. Parker Smith received the C.B.E. in 1942 in recognition of the notable contributions which he had made to the advancement of electrical science.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

REGIME FLOW IN A SILT CARRYING CHANNEL

Sir,—Mr. Cooke, in his article on regime flow in your issue of July 10, 1953, makes a valuable contribution to the subject of flow in alluvial self-formed channels. The canal which he cites was not, strictly speaking, a regime channel, as the silt or sediment admitted, both in respect of grade and quantity, depended on the regulation of the headworks on the Blue Nile. As there was ample fall available at the head this particular channel was enabled by the deposition of silt in the upper reach to build up a water surface slope competent to transport the charge admitted, and a condition of equilibrium or stability was thus established. It is important to note that this channel, although initially wider than necessary, was effectively held at the sides. This condition is very different from that which obtains in a river without embankments and flowing in its own alluvial plain. A river subjected to a heavy bed load may adopt the expedient of meandering, or moving to a flank, throwing down a part of its load and sweeping forward a diminished charge to the sea.

Canals of the type quoted by Mr. Cooke are commonly termed "regime channels" in India, Pakistan, and the Sudan, and their hydraulic data present many similar features. This family resemblance must be associated with the quantities of silt or sediment normally admitted to the canal systems in these countries. Changes in regulation of the river barrages may affect the grade of the material thrown down on the bed, and also the quantity of both bed and suspended load.

It is possible that for all natural alluvial silt transporting channels there is an ideal "optimum," or "regime," charge, and this charge, since a mobile bed presents less resistance, is probably the minimum consistent with a fully active and mobile bed, a condition which involves turbulence. When the silt charge admitted to a canal is small enough to approximate to a regime charge, equations, such as those of the writer, can be applied to the design of canal systems deriving their supplies from rivers of which the general characteristics are known, and are particularly useful when these canals are remodelled or extended, as the records of the channels previously constructed present the engineer with invaluable experimental data.

It is clear that in all regime equations there is the tacit assumption that regime channels are associated with a regime silt charge. It is possible to adopt the simplifying assumption that a fine silt with a heavy charge may behave in the same manner as a somewhat coarser material with a regime charge, and in respect of the velocity-depth relationship this assumption which the writer made is substantially correct. When, however, the width is involved there is not the same warrant for linking the grade and charge inseparably and Sir Claude Inglis was one of the first to urge that after every allowance had been made for "shock" in alluvial channels and inevitable observational error, the "scatter"

was due to the omission of the charge as an independent variable.

In his recent work *The Behaviour and Control of Rivers and Canals*, Sir Claude Inglis has put forward provisional modifications of the writer's original equations of 1930. The suggestion has frequently been made that the charge should enter the equations as well as the diameter of the particle, but Sir Claude has added yet a third variable, the terminal velocity of the particle in water, V_s, and in this respect his equations are unique as all three variables are made to enter. His equations, which can be reduced to a greatly simplified form, would indicate that when the bed material is sand the width is a function of the charge and independent of the grade or terminal velocity, that the depth is a function of the charge and the terminal velocity, and that the diameter of the particle, alone, enters the correlation of the velocity, depth and slope. These equations are illuminating and valuable.

Mr. Cooke could have tested the hydraulic data of his regime canal without recourse to the silt factor. Thus, the general regime equation of the writer, irrespective of silt grade, is in metric units :

$$V = 10{\cdot}77\, R^{2/3} S^{1/3}.$$

It will be found that the actual velocity in the canal, with a discharge of 74,000 cubic metres a day, is 0·3807m per second and the computed velocity 0·3789m per second. The very close agreement is fortuitous, but whatever the precise figure adopted for the "dominant" discharge may be the agreement is exceedingly close. The close approximation of the canal cross section to a semi-ellipse is due in part to the fine bed material and in particular to the fine cohesive material in suspension. This also accounts for the fact that the channel is somewhat narrow. Coarser bed material with less suspended silt would make the channel cross section more dish shaped, and a very heavy and uniform bed load would lead to a cross section with an approximately horizontal bed. This is very seldom encountered in normal canal practice, and in the writer's experience most natural alluvial channels, except when they are in the interweaving or braided stage, have curved beds.

Hindhead, Surrey, GERALD LACEY
August 12th.

"BRITANNIA" LOCOMOTIVES

SIR,—I am accused of partisanship against British Railways in my remarks concerning their "Britannia" class locomotives, published in your issue of August 7th. I will plead guilty with the greatest of pleasure, provided that my accuser, Mr. Nock, will be as frank concerning his own glowing tribute in favour of these locomotives. So many engineers now sail with the wind (a very apt simile !) in acclaiming everything done by British Railways, that in practice the other side of the picture rarely comes to the fore. Only when both viewpoints are on the table together can an assessment of, say, the merits of a particular locomotive be arrived at fairly.

However amusing such interchanges of words may be to read, we are concerned here only with facts, and certainly not with "deep emotions." Since Mr. Nock has apparently misunderstood my point in connection with locomotive performance in East Anglia, it is possible therefore that others may have done the same. I am, of course, quite aware that there has been a considerable improvement in running in that part of the country ; indeed, British Railways give us no opportunity to overlook the fact, since it is the only instance where any speeding up of schedules can be attributed to the introduction of their "Britannias" alone. It is singularly unconvincing to find, however, that those responsible had to introduce an engine of no less than 94 tons weight, with corresponding increases of theoretical boiler and tractive power, in place of one of 69½ tons, before they could achieve these improvements. Put simply, if you increase the size of engine in use by nearly 50 per cent, the fact that you can then speed up your trains proves precisely nothing concerning the merits of that particular design, by comparison with others of equivalent size. It only proves that such a locomotive is not a complete failure, which no one has yet suggested that the "Britannias" are.

Manchester, R. G. B. GWYER
August 16th.

THE ELDERLY ENGINEER

SIR,—Your issue of August 14th contains both an article by Mr. C. E. R. Sams, entitled "The Elderly Engineer," and your editorial comment thereon. Many members of this Guild are pressing for much more help to be made available to elderly professional engineers seeking employment, and my Council is actively pursuing means of doing so. Mr. Sams has given the Guild invaluable information and advice, and his pioneering effort in this field is widely acclaimed. It may be that the facilities at the Guild's disposal will enable a wider and more intensive attack to be made on the problem. There can, nevertheless, be no quick solution. The first stage must be to create a new attitude of mind amongst employers, an attitude which will recognise the worth of mature judgment and ripe experience, and which will actively seek the appropriate ways and means of employing these qualities of age. It is to this first stage that the Guild has already set its hand.

J. H. W. TURNER,
London, Honorary Secretary,
August 24th. Engineers' Guild.

Contractor and Sub-Contractor—Liability for Workmen's Injuries

By SIR WILLIAM BALL, O.B.E.

IT is a curious fact that the question whether a contractor can pass on his liability for a breach of the statutory regulations to a sub-contractor has not been decided until quite recently. The point arose in the case of Mulready *v.* J. H. and W. Bell, Ltd., and Another (1953) 2 A.E.R. 215, which came before the Court of Appeal on May 12th. Some points which are of interest to employers on the question of damages and costs were considered at the same time.

The facts were these: Bell, Ltd., the first defendants, to whom we shall refer as the contractors, agreed to do certain work in the construction of a factory belonging to the second defendants, the factory owners. The contractors employed a sub-contractor to do part of the work, comprising the installation of three ventilators in the roof. The plaintiff, a labourer employed by the sub-contractor, while engaged on the work, fell 70ft and suffered injury, including the loss of a leg. He brought an action against the contractors and the factory owners. As against the latter, his claim was founded upon an alleged breach of the Factories Act, 1937, Sec. 26 (2), which imposes a duty to provide means to ensure the safety of a man working on a roof. This claim was dismissed with costs on the ground that the premises were not yet a "factory" within the meaning of the Act, and we shall only refer to it a little later on the question of costs. As regards the contractors, the claim was based on an alleged breach of the Building (Safety, Health and Welfare) Regulations, 1948, Reg. 31 (4). Reading it shortly, this regulation provides that "every contractor and employer of workmen" shall comply with such of the requirements of Reg. 31 as relate to any work, &c., to be performed by him. Reg. 31 (1) provides that where work is done on a sloping roof, precautions must (in certain cases) be taken to prevent a man falling. It was submitted on behalf of the contractors that these precautions had to be taken by their sub-contractor (counsel pointed out that there was no case to be found in the books in which a head contractor had been held liable in these circumstances) and not by them. Mr. Justice Pearson, who tried the case, refused to adopt this argument, holding that the defendants were still in effective charge and control ; that they were undertaking an "operation" and were performing the act of fixing the ventilators. He gave judgment for the plaintiff, that is to say, assessing the general damages at £7600. As to this judgment—so far as the question of liability was concerned—Lord Goddard said, in the Court of Appeal : "A duty was cast on the contractors, who had undertaken to perform the roof work, and they cannot avoid it by sub-contracting." He then referred to the well-known case of Dalton *v.* Angus (1881) 6 A.C. 140, in which Lord Blackburn, having so enunciated the law, said : "He may bargain with the contractor that he shall perform the duty and stipulate for an indemnity from him if it is not performed. But he cannot thereby relieve himself from liability to those injured by the failure to perform it." He went on to point out that, although as between contractor and sub-contractor the point was new, it had been held long since that a local authority owes a duty to the public. He referred to Penny *v.* Wimbledon U.D.C. (1899) 15 T.L.R. 348. In that, a highway authority had employed a contractor to make up a road. Owing to the failure of the contractor to light up an obstruction a wayfarer was injured. It was held that an obligation was thrown upon the highway authority to see that proper precautions were taken and that liability could not be avoided by throwing the blame on the contractor. Lord Goddard said that this principle applied whether the duty is owed to the public or only to a section of the public, and this, although a breach of regulations, is a criminal offence, and may be the subject of a fine for payment which he who employs a sub-contractor could not bargain for an indemnity.

And so there it is. If a contractor desires to avoid having to pay damages resulting from a breach of building regulations by a sub-contractor he should secure an indemnity. A clause which is to be found in the R.I.B.A. form of contract clearly recognises that a contractor cannot be called upon by the architect to employ a sub-contractor who will not submit to giving an indemnity.

Now, to mention another point which emerged in the determination of this case. The learned judge who tried it assessed the general damages at £7600. There being special damage as well, he gave judgment for £8500. The Court of Appeal, while recognising that injuries were serious—the plaintiff had lost a leg—considered that the sum of £7600 was excessive and reduced it by £2000, so that judgment passed for £6492 10s. in all. Lord Goddard said in the course of his judgment : "The injuries in this case are unfortunately of a class that are all too common in motor-car collisions as well as in industrial accidents, and, while no doubt damages are properly higher than they used to be, reflecting the decreased value of money, we feel obliged, even with some regret, to make this reduction."

There remains to consider an interesting point which arose on the question of costs. We have seen that the action was brought against the factory owners and the contractors. The owners put up a successful defence and were awarded their costs. The contractors having been held liable, the plaintiff naturally asked for and obtained an order for costs against them ; but he did more : he also asked that they might also be ordered to pay the costs which he had to pay to the factory owners. That such an application should have been made at all may seem odd to one who is unfamiliar with the forms of law. If a litigant chooses to bring an action against Smith and Robinson and fails as against Smith, why should Robinson be asked to pay (to all intents) the whole costs of the suit? Here is the explanation. It has been held to be right to lay such a burden on Robinson in certain circumstances. Where, for example, a person is injured by an accident resulting from a collision between two cars, it may be impossible to say which is liable. It might then be reasonable to sue both and to make the one liable pay all the costs. In the case under notice, however, the cause of action against the factory owner was quite distinct from that for which the contractor had to suffer, and the Court of Appeal decided that the plaintiff must pay the factory owner's costs himself.

Fifty Years of Undercarriage Development

No. II—(*Continued from page* 247, *Aug.* 21*st*)

Having traced the development of the fixed undercarriage, this article now refers to subsequent developments which preceded the jet engine and the tricycle landing gear. The general application of the oleo-pneumatic leg and of the retractable undercarriage is noted and some typical units described, excluding the later development of " liquid " spring units.

EVOLUTION of the aeroplane over the next decade assumed a more leisurely pace if the development of civil aircraft is regarded as a criterion, particularly in this country, where, until about 1935, the majority of aircraft were still biplanes, largely fabric covered and having fixed undercarriages using springs or rubber in conjunction with oleo dampers. But in great secrecy intensive military preparations, not only in Germany, had succeeded in cloaking a transformation of the profile and performance of the flying machine. For although the world was still ostensibly at peace, it is significant now to consider the aircraft which first flew in the years 1935 and 1936. In a formidable list appears the " Messerschmitt," the "Fortress," the "Whitley," the "Hurricane," the "Wellington" and "Spitfire," the " Junkers 88A," the " Blenheim " and the " Heinkel III." Virtually overnight had the biplane been banished and with it went the fixed undercarriage. For cruising speeds had jumped from just over 100 m.p.h. to well over 200 m.p.h., and the fixed undercarriage suddenly looked as antiquated as did the tail-wheel aircraft at the end of the last war.

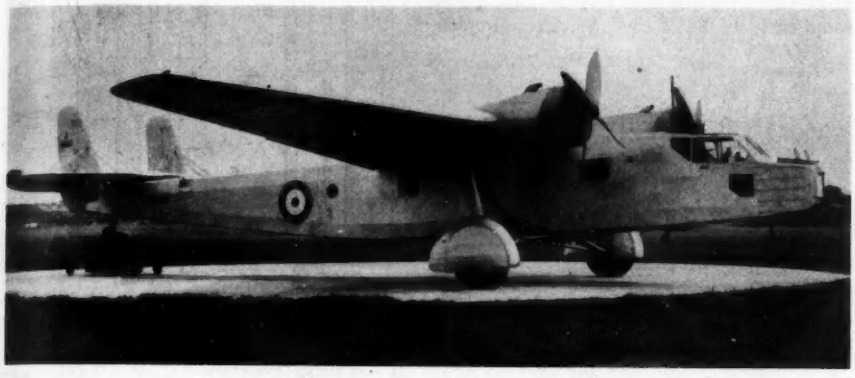


Fig. 13—The Handley Page " H.P." Transport

No longer pleading simplicity could aircraft harbour their homely and assuring profiles, nor unfortunately, were they to retain that degree of safety the like of which they were not likely to enjoy again. In the design stage at that time were a host of other aircraft which first flew in 1939–40, whose specifications were virtually to conclude the evolution of the piston-engined aircraft. The " Liberator," the Douglas " Sky-master," the " Boston " and " Mitchell " bombers, the Lockheed " Lightning," and the " Cobra " fighters, were amongst some American machines which first flew then, all of which incidentally, illustrated the strength of that country's early preference for the nose wheel system of suspension, which has since been almost universally adopted.

Before the monoplane the undercarriage had been only one of several undesirable excrescences, but at cruising speeds of little more than 100 m.p.h. the advantages of retracting the legs (which had become well streamlined) were not such as to justify its complications, particularly those arising in a biplane. Like so many of the later advances in aviation, however, its application had not been overlooked by the pioneers, and one notes that as early as 1919 Curtiss had fitted to a biplane with a 45 h.p. two-cylinder engine a simple hinged vee strut and rigid axle suspension which could be retracted into the fuselage during flight, leaving only the lower half of the wheels exposed. A similar system was tried in a modified Sopwith " Pup " naval machine, but its retraction was not mechanically controlled, as it was only required to improve hangar space.

The oleo-pneumatic leg itself was not generally adopted in this country until the beginning of the 1930s ; but, following the retractable systems of the prototype fighter and bomber aircraft in 1935, its use became almost universal. A common fixed, but heavier, system had been that of the oleo damper, used in conjunction with rubber or steel springs, and even retained in the retractable systems of the " Ensign " and " Whitley " aircraft of 1937. The general form assumed by the larger fixed installations employed half axles hinged to the fuselage with the wheel end located by the telescopic leg and a drag strut, the installation shown in Fig. 13 being typical. The development of the smaller fixed undercarriages up to this time is well illustrated by the fully cantilevered legs fitted to the Gloster " Gladiator " (Fig. 14).

A particular application of a coil spring is that of the internally sprung wheel used with this design. The wheel rim turned on the disc in which the fixed axle was constrained to ride against springs in a vertical slot. The Gloster " Gladiator " and the Westland " Lysander " were amongst aircraft fitted with this suspension. It was, in fact, a first fortuitous Japanese order in 1931, for a few of these wheels, which provided the incentive for the inventor, Mr. G. H. Dowty, to acquire a workshop.

Amongst some early installations in 1934 mention might be made of one patented by the Messier Company in France and incorporated in a monoplane of its own design.[1] A central tandem wheel arrangement was adopted and it was the first aircraft to fly in Europe with a hydraulic retractable undercarriage. In conception this system was in advance of requirements in several respects, but has recently gained prominence in America, where the use of thin wing root and pod-mounted engine configuration has enforced fuselage mounting of the undercarriage. The oleo cylinder of each leg communicated through piping to a common orifice and a hydraulic accumulator, and the aircraft's centre of gravity was arranged to be slightly forward of the mid point of the wheel centres. The area of the cylinders was proportioned to their distance from the centre of gravity. Wing outriggers were used to provide lateral stability. A fixed tandem gear of this type had been used even before this application in the Westland " Pterodactyl."

The principles of oleo-pneumatic damping and recoil agents were already well known in connection with military weapons, and it is not surprising that one of the earliest patents* (1915) was taken out by Vickers-Armstrongs, Ltd. It was the first design to provide

* Patent No. 568/15.

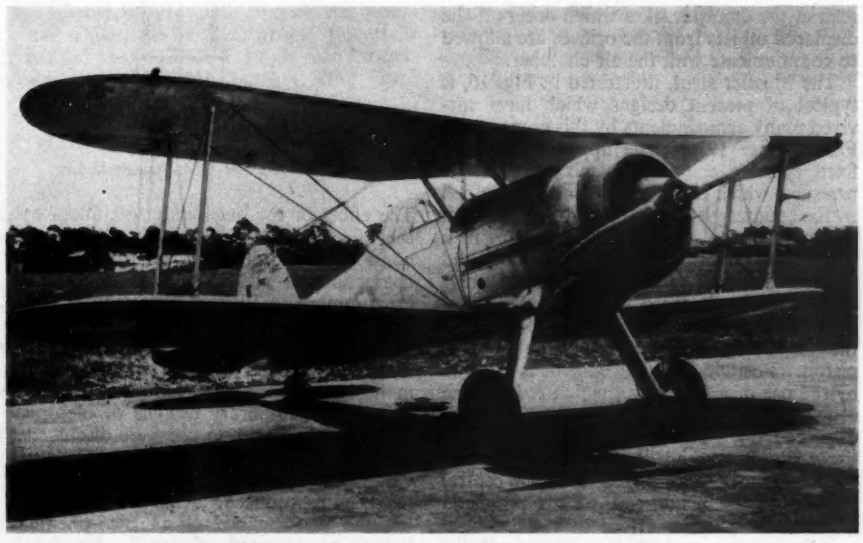


Fig. 14—Internal Sprung Wheel on the Gloster " Gladiator I "

for positive control of the fluid during the rebound stroke, which is necessary if cavitation is to be avoided during taxi-ing. An example of the earlier and cruder forms of unit, to which we referred earlier, is that shown in Fig. 15, which was patented as early as 1908 by Esnault-Pelterie (Patent No. 28026). The manufacture of the oleo-pneumatic leg introduced several manufacturing problems, which are mentioned later in this account, and with some notable exceptions manufacture of this unit and other items involved in the landing gear of aircraft were increasingly undertaken by specialist manufacturers.

The best of the early designs of the Vickers, Dowty and Messier companies included most of the essential functions in common

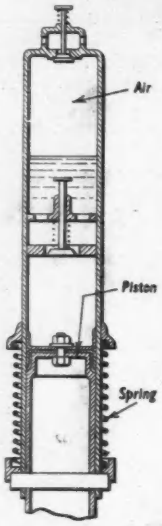


Fig. 15—An Early Oleo-Pneumatic Unit (1908)

use to-day, and particularly since the beginning of the World War II have remained substantially the same in detail. Over the whole period their development has largely taken the form of persistent increases in the strength to weight ratio of the wheels, tyres and cylinders, improved strut efficiencies, higher dissipation capacities and improved rebound control characteristics.

Installations at one time fell into two main categories: those providing a variable orifice area over the stroke and those employing fixed area orifices. Another distinguishing detail relates to the use in some installations of a free or counter piston to avoid or restrict the emulsification which occurs if the displaced oil jets from the orifices are allowed to communicate with the air chamber.

The Messier strut, illustrated in Fig. 16, is typical of present designs which have survived many arrangements by this company in France since 1928. The upper part of the fixed cylinder contains the air under static pressure, which is compressed and contained by the counter piston. This piston is fixed to the main piston by a rod which slides in a diaphragm containing the main orifices and secured to the outer cylinder. During closure oil is displaced through all the diaphragm orifices into the rebound volume, the air being compressed by the counter piston. Positive rebound control is effected by the use of a flap valve, which reduces the orifice area available for the return of the displaced oil. The system employs a relatively simple method of obtaining a variable orifice—that of milling grooves in the central portion of the piston-rod. Thus provision is made for a larger orifice over the central portion of the stroke where the maximum velocities obtain. As taxi-ing displacement is also largely confined to this section of the rod, a softer suspension is claimed.

The "inverted" form of this strut—so called when the cylinder moves over the piston—is also illustrated (Fig. 17a). This arrangement has the advantage of being characteristically shorter, but because the rebound chamber must have a smaller diameter, a percentage of the displaced oil is ejected into the air chamber. On the other hand, this percentage is able more rapidly to refill the bottom chamber on extension via the bore of the piston-rod and through the lower flap valve, thus reducing cavitation during rapid cyclic operation when taxi-ing. A positive rebound control is obtained, as the oil trapped on the rebound volume can return only through the annular space between the piston-rod and the fixed cylinder head.

Another method of obtaining a variable orifice involves the use of a tapered rod or metering pin of various sections sliding in an orifice. This characteristic was incorporated in the original Vickers patent and was used by the company up to and including some early marks of the "Spitfire" aircraft.

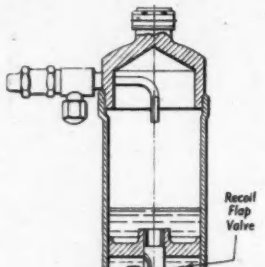
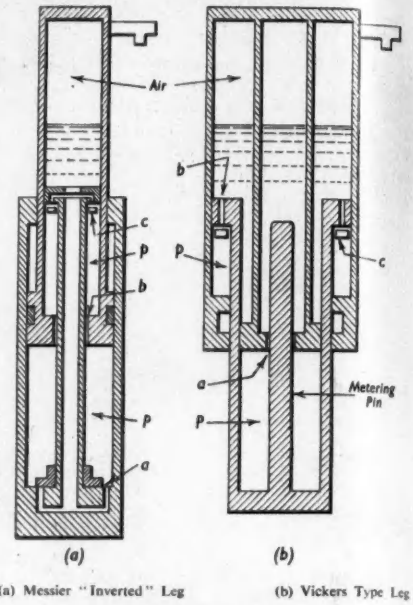


Fig. 16—Messier Oleo-Pneumatic Leg

The effect of the machining tolerances upon the effective flow annulus, however, had a considerable influence on the reaction characteristics and this detail is no longer incorporated in Vickers installations to-day, although it is retained in America, where the Vickers type leg is still popular. A diagrammatic illustration of the Vickers oleo-pneumatic leg is reproduced herewith (Fig. 17b). Several contemporary designs of oleo-pneumatic legs in common use were discussed by Jones and Cook[2] in 1938 and more recently by Conway[3] in a paper from which Fig. 17a and b has been reproduced. A method of calculating the performance of an oleo-pneumatic leg, using assumed efficiencies for the leg and tyre, has been published by Hadekel.[4]

Undercarriage Geometry

In single-engined fighter aircraft the leg was often fully cantilevered, being retracted sideways into the wing by a transverse acting jack. With heavier multi-engined aircraft, where the leg was commonly retracted backwards into a nacelle, a divided leg using side-by-side braced oleos and a central wheel were generally used (Fig. 18). This arrangement not only had a higher strength/weight ratio than a single leg with a cantilevered wheel or half fork, but was more conveniently retracted



(a) Messier "Inverted" Leg (b) Vickers Type Leg

P—Oil under pressure on closure.
p—Oil under pressure on rebound.
a—Closure orifice.
b—Rebound orifice.
c—Special flap to avoid cavitation.

Fig. 17—Two Oleo-Pneumatic Leg Units

and housed. Each oleo was braced against drag loads by articulated radius rods, which extended to the bottom of the fixed cylinder. The system used on the "Dakota" of connecting the radius rods to the wheel axle or sliding member, and used also on the "Heinkel III" and the "Anson"—these being three of the first mass-produced aircraft to use a retractable undercarriage—lost favour. Although it reduces the radial loads on the sliding members, it can only be used with a geometry where the oleo is not simply pivoted, the radius arm needing to be solid and the oleos taking a knee joint.

Normally the legs have a forward rake in tail wheel configurations, the angle being largely influenced by stability considerations which determine the location of the external wheel reaction in relation to the centre of gravity and hence the wing spar on which it usually hinges. The load/drag resultant is not taken axially by the strut, and furthermore, in cases where the wheel axle is cantilevered, the axial component must be laterally eccentric. Hence the resolved component perpendicular to the strut at the wheel axle is reacted between the bearing surfaces on the lower end of the fixed tube and the upper end of the sliding tube, and gives rise to frictional forces resisting closure. The magnitude of the bearing reactions—these always being greater than the applied radial component—in the two couples formed, having as their arm the tube overlap, are directly related to the ratio of the overlap to the overhang of the wheel measured axially from the lower bearing, in one case, and measured laterally on the other hand if the wheel is cantilevered. The higher these ratios the

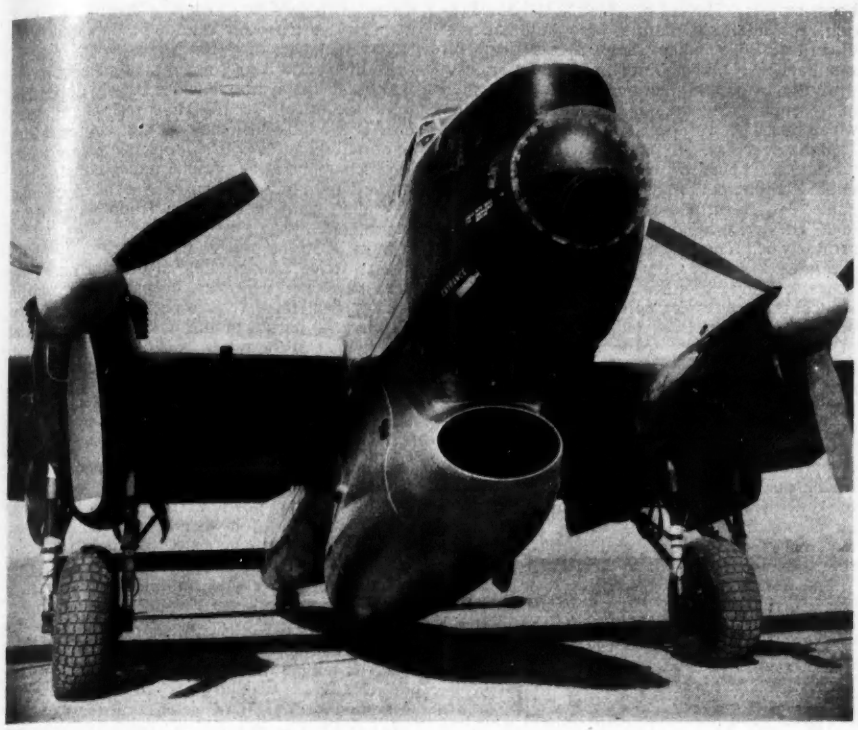


Fig. 18—The Avro "Lancaster" Bomber

lower can the bearing loads be kept, but the greater becomes the overall length and the weight.

In the early days there were repeated failures due to complete seizure in particular installations where the wheel overhang appreciably exceeded the tube overlap. It has been stated by one manufacturer that this ratio of overhang to overlap should not exceed 1, with which ratio the overall length of the leg cannot be less than 3·5 times the stroke, and consequently often determines the height of the aircraft.

With aircraft up to medium size it has been safe practice to form the leg solely from a single fixed and sliding tube. With larger aircraft a common and sometimes lighter arrangement has been to use three or four cylinders. With the latter design, telescoping external tubes fixed to the wheel and aircraft respectively take all the bending loads, whilst inside them and freely housed in the closed ends are the oleo-pneumatic tubes. As these latter tubes are then loaded axially the glands and piston rings have to function under much reduced tube curvature and are relieved of the former couple reaction loads. With three tubes the lower external tube acts also as the sliding member of the oleo-pneumatic unit and consequently the degree of "flotation" obtained is reduced.

Several methods have been used to reduce the constraint imposed by the bearing surfaces on the sliding tube. These have included spherical seating, bearings, special roller bearing housings, and synthetic resin, but in many cases ordinary fixed bushes have been retained. The brief references here to leg geometry are discussed fully by Conway.[3]

Where wing engine nacelles were available the use of braced oleo-pneumatic units side by side and carrying the wheel centrally, has been common practice (Fig. 18 shows a Dowty unit). This system was used on most multi-engined aircraft during the war, with radius rods extended to the lower end of the fixed leg. On the Messier versions fitted to some marks of another heavy aircraft, the "Halifax," a single bridge casting of magnesium alloy was employed in which the oleo tubes were housed (Fig. 19).

In most post-war civil aircraft the need to use twin side-by-side wheels on each leg has led to the use of a single oleo braced by an integral torque bracket, (Fig. 20).

The use of articulated landing gear had little application in this country for main leg systems, until the comparatively recent application of the Dowty levered systems, using liquid springing, as will be described in Part III of this series of articles.

It will be recalled, however, that the "Siskin" aircraft, described in Part I, used such a system (leverage 1 : 1), whereby the wheel was carried on an arm pivoted to a rigid structure with the oil dampers pivoted between the axle and the fuselage. A similar system, but made retractable, was used much later on German and other Continental designs. The Focke-Wulf Flugzeugbau G.m.b.H. employed this principle on

Fig. 20—Twin Wheel Main Leg

at least two of its pre-war designs, the "FW 58," a twin-engined trainer, and the FW "Condor," a transport of 32,000 lb all-up weight, and improved forms were adapted on some later fighter and bomber machines. Each main wheel on the "Condor" was carried between two forward arms, which were pivoted to the apices of two tubular triangulated legs. Oleo-pneumatic units were connected between the wheel axle and near mid points on the foremost leg members, the latter being longitudinally braced by hydraulic jacks and so hinged as to make the installation wholly retractable within the engine nacelles. The "FW 58" employed a trailing wheel fork, similarly carried from tubular vee structure which was

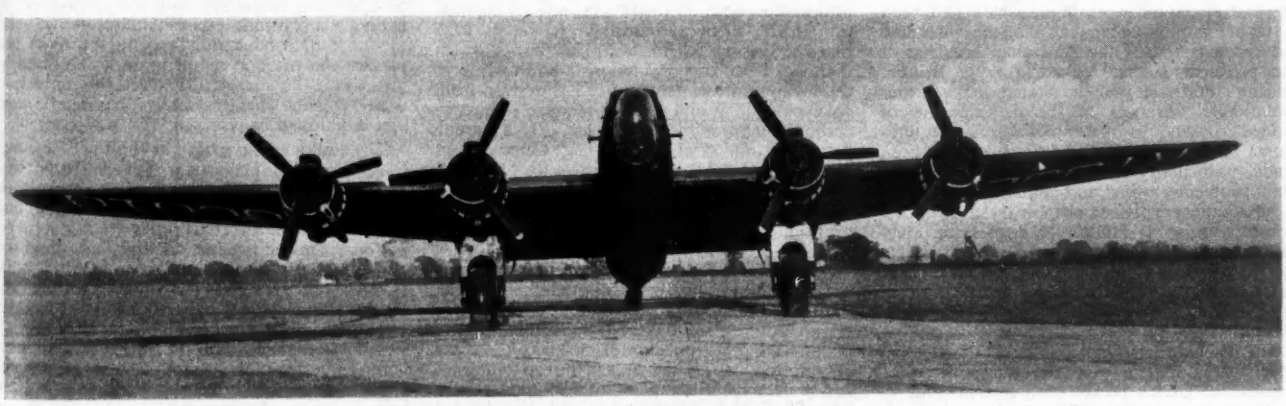


Fig. 19—The Handley Page "Halifax" Bomber

hinged within the engine nacelle, its apex being located by an oleo-pneumatic jack by which the complete installation was retracted. On the later "FW 189A" and on the "FW 154A" a twin-engined all-weather fighter, a short vertical retractable tubular strut was used from which to hinge a wheel fork, the oleo-pneumatic units being hinged at each end of the wheel axle and rigid structure.

By the end of the war Heinkel was using an articulated system incorporating a lever advantage on two heavy aircraft—the "He 177A," of 68,000 lb, which employed four engines driving two propellers, and the "He 274," of 79,000 lb. These were also amongst the first large notable German aircraft to adopt the nose wheel undercarriage. In cases where the shorter leg is an essential requirement, as it was in the case of the "Meteor" aircraft, the levered system has undisputed advantages for main leg design and functionally represents the most elegant of all solutions to the undercarriage problem. Mechanical shortening of the leg during retraction is also easier with this system, as used on "Meteor" and "Wyvern" aircraft. Against its general application, however, it has been argued that the unit is characteristically heavier than a comparable telescopic leg, due, it is maintained, to the substantial bearings required at the pivot and on the lever, which are both subject to the full landing reaction and to the fact that as the pivot load is eccentric, the leg is subject to couples of considerable magnitude.

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(*To be continued*)

British Guided Rockets

THIS week Mr. Duncan Sandys made further disclosures on the development of guided missiles in this country and in Australia. The Minister has now gone to Australia to discuss this new industry with the Australian Government and to inspect the Woomera rocket testing range.

He recalled that the development of these rocket weapons was carried out initially in Britain by the experimental establishments of the Ministry of Supply, or by outside firms in industry. After a weapon had undergone preliminary firing tests here, it was sent to Australia, where full-scale trials with explosive warheads could be carried out over land on the rocket range at Woomera. If in the light of these trials modifications were needed, they could for the most part be carried out in the extensive engineering and electronic workshops, which had been set up in the vicinity of the range by the Australian Government and by the Australian branches of the principal guided rocket firms in Britain. During the past year he stated that further remarkable advances in the development of guided rockets, to meet the various requirements of the three Fighting Services, had been made, particularly in connection with the two main problems—speed and guidance.

Mr. Sandys explained that in order to tackle bombers flying as fast as or even faster than sound, and at heights above 50,000ft, rockets had to travel at more than 2000 miles an hour. In achieving that performance, many technical problems of great complexity had had to be solved.

To be able to intercept and destroy an approaching raider before it could release its bombs, the guided rocket must lose no time in building up its velocity, which, he continued, made it necessary to fit the rocket with auxiliary boost motors. Having provided initial acceleration, the auxiliary motors were automatically discarded. To make these boosts drop off simultaneously and smoothly, without interfering with the course of the missile, had presented many engineering and aerodynamic difficulties which had, however, been successfully overcome.

Manœuvrability.—In referring to their manœuvrability he believed with confidence that no piloted aeroplane could hope to out-manœuvre guided rockets of the types we were now developing. They were capable of high-speed twists and turns, which created such intense strains and pressures as neither the human body nor the wings of any aircraft could withstand. To reduce these stresses, continuous efforts were being made to reduce weight through the use of lighter materials. New methods, he said, had been evolved for moulding large plastic structures, and before very long it might be possible to make the whole of the rocket's casing out of these light materials instead of metal.

Guidance Mechanism.—The most complex component of a guided rocket was its steering mechanism. In some cases that might contain ten times as many valves as a large television set, all of which had to be fitted into a missile a few inches in diameter, and had to be made robust enough to withstand the shock of firing.

The Minister then discussed two kinds of rockets, of which one was known as a "beam rider." That kind followed a radar beam which covered the target automatically and was operated from the ground. Even at long ranges they could keep themselves within a few feet of the centre of the beam.

The other kind of missile were known as "homing rockets," which, as soon as they had been launched, took over control completely. They locked their guidance mechanism on to the enemy plane and, without any further assistance from the ground, steered towards it, changing course as necessary. Unlike ground-controlled "beam riders," their accuracy was unaffected by distance. In fact, the nearer they approached the target the stronger its "scent" became and the easier it was to "home" on to it.

Mr. Sandys concluded by referring to advances which have been made in the development of guided rockets to be launched from fighter aircraft. These will increase the killing power of our fighters many times over, and will enable them to engage an enemy bomber from a distance beyond the range at which it can defend itself with any conventional aircraft gun. Our efforts, he said, had been concentrated on the problem of defence against enemy air attack. For this purpose a series of missiles had been evolved—some to be launched from the ground, some from ships and some from fighter planes. Whilst these anti-aircraft weapons would be the first guided rockets to be brought into service, they would be followed by other types for use in various artillery and bombardment roles.

Oils from Coal

SINCE 1935 the Fuel Research Station at Greenwich has carried out research and development work on the Fischer Tropsch process, and as a result the station has available considerable information both on the process and its application to the chemical industry. It was in 1925 that the German chemists Fischer and Tropsch discovered that carbon monoxide and hydrogen, the main constituents of water gas derived from coke or coal, would form a mixture of hydrocarbons, approximately equal to a crude petroleum oil, at about 200 deg. Cent. and at atmospheric pressure, in the presence of nickel, cobalt or iron catalysts. It is this reaction which is the basis of the Fischer-Tropsch synthesis for producing petrol, diesel and jet fuels and many chemical products from coal.

A total of 500,000 tons of various products was produced annually by nine German plants during 1939–45 by the process, and as a result of research the United States has built a commercial plant having a capacity of 300,000 tons per annum and the United States Bureau of Mines has a demonstration plant of 300 tons a year capacity. Both in America and the United Kingdom interest in the process is mainly concerned with possible shortage of natural oil, since at present the process cannot be operated upon an economic basis. This is due to the relative price of oil and coal, since the major cost of the making of the synthesis gas is largely dependent upon the price of coal. However, where cheap coal is available synthetic oil can compete with imported oil and a 200,000 tons per year Fischer-Tropsch plant is at present under construction in the Union of South Africa and the erection of a similar plant in Southern Rhodesia is being considered.

Since 1936 the process has been greatly modified; active and durable iron catalysts have been developed which are cheaper and result in greater flexibility with respect to process conditions, the nature of the gaseous raw material and to that of the products obtained. The ratio of carbon monoxide to hydrogen now can be varied widely and even a mixture of carbon monoxide and steam can be used as a feed material, while temperatures from 200 deg. to 350 deg. Cent. and pressures from one to fifty atmospheres can be employed. Reaction products can consist of gaseous and low-boiling olefins, making possible the production of 80 octane fuel, or of 60 per cent of solid waxes. The products can consist of mainly hydrocarbons or predominantly of alcohols, while the primary products are suitable for converting into lubricating oils, fatty acids and detergents.

The reaction is strongly exothermic and production is dependent on the control of the catalyst temperature by the removal of the heat of reaction. Originally a fixed bed of catalyst granules packed into water-cooled tubes was used and the temperature controlled by releasing steam into the system. This gave a low rate of heat transfer and limited the reactor throughput, but improvements have resulted in a fivefold increase in the space-time yield. However, in a pilot plant, a space-time yield twenty times greater has been achieved by the use of the "fluidised-solids" technique, in which higher rates of heat transfer can be obtained. The system has a disadvantage, in that it requires a narrow range of conditions and is restricted to the production of gaseous and low-boiling hydrocarbons and low-molecular weight oxygenated compounds. The first stage of the South African plant is to have improved fixed bed reactors, while the second stage will employ a special form of fluidised catalyst system developed by the M.W. Kellog Company.

Liquid-phase systems, in which the catalyst is in direct contact with a non-volatile liquid cooling medium, have been tried and although the medium retards the reaction rate, efficient cooling is obtained and the production of undesired products, such as methane, minimised. The Fuel Research Station of the Department of Scientific and Industrial Research considers that the most promising of these techniques is the slurry process, in which a finely powdered catalyst is suspended in molten wax and synthesis gas is passed through the suspension. Volatile reaction products pass out with the effluent gas stream, while the non-volatile waxes and heavy oil remain in the slurry and are removed by means of a filter to maintain a constant liquid level in the reactor. Both the liquid-phase slurry and fluidised-catalyst systems permit the continuous replacement of catalyst and so maintain a constant level of catalyst activity and therefore of product quality. In the fixed bed process the reaction temperature is increased at intervals to maintain the level of conversion until the point when the catalyst has deteriorated and requires to be replaced.

The equipment available at the Fuel Research Station of the Department of Scientific and Industrial Research includes laboratory-scale units for catalyst development and testing, and for studying the effect of process conditions on performance and product quality. Two fluidised and four liquid-phase units are available for the study of process techniques, and a pilot plant of 50/60 gallons per day capacity has been built to obtain chemical engineering data for reaction systems and to facilitate the design of a suitable commercial reactor. Fundamental aspects of catalyst action and reaction mechanisms have been investigated and in the current work radioactive carbon is being used as a tracer.

A Limpet Dam and Tunnel for Lock Gate Renewal

IN our issue of July 24th last, we gave some details of the work being carried out at the hydraulic laboratory of the Docks and Inland Waterways Executive. One of the investigations recently undertaken by that laboratory concerned a method of repairing the quoins, gate pintles and sill of a lock, in preparation for the fitting of new gates. An original method of carrying out such repairs had been suggested and a model of the limpet dam and tunnel which this method envisaged was made and tested at the laboratory. It was concluded that the method was a practicable one, and it has since been used at the Regent's Canal Dock, where the outer ship lock gates, forming the sole outlet from the dock to the River Thames, have been renewed.

The work to be done on the lock itself in preparation for the new gates involved replacement of the gate pintles, dressing the granite quoins and replacement of the old timber sills with steel castings. The dock has only one entrance, and it was important that the underwater work should be carried out with a minimum of interference to shipping. Consideration was given to having the underwater work carried out by diver, but this idea was discarded as it was considered that the setting of the pintles and sills to the existing granite, which was known to be damaged, in water too heavily laden with silt to permit visual working, would be a protracted operation and the accuracy of the setting would be problematic.

The use of a half-tide caisson dam was next examined. With shipping restricted to use the lock for three hours at each tide, the dam could be used in the interim period. Allowing for positioning the dam, pumping out the lock chamber and removal, at the best two to three hours' work between tides could be expected. After careful consideration it was thought that this method would be lengthy and too costly.

The work of dressing the quoins and setting the pintle could, however, be carried out by the well-tried method of a limpet dam placed against the wall of the lock, and by working on one side at a time shipping could still pass. This method still left the problem of setting the new sills, and as a solution the ingenious scheme mentioned above was devised by the engineering staff of the South-Eastern Division of the Docks and Inland Waterways Executive for the construction of an underwater tunnel using the limpet dam as the vertical shaft.

Details of the limpet dam and tunnel are shown in the accompanying drawing. They were made of steel of semi-circular section 8ft in diameter in four pieces, namely, (1) the limpet dam with flanged connections, top and bottom, for permitting it to be used on either side of the lock and for attaching the tunnel section ; (2) a straight tunnel section ; (3) a mitred section ; (4) an end plate shaped to the step of the sill.

The limpet and the tunnel were of welded construction consisting of a steel shell of ¼in plate suitably stiffened with transverse ribs and longitudinal bars, the stiffened shell being welded along the edges to 8in by 3in steel channels. Stiffened flanges were welded externally at the extremities of the shell for bolting the sections together. The steelwork, which had a total weight of only 14 tons, was fabricated by Towler and Sons, of Stratford, London, E.

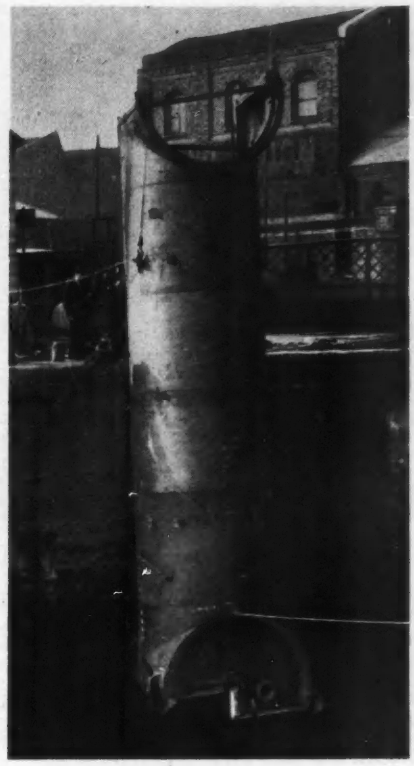
Oak timbers were fitted into the channels to carry the packings with which the joint between the limpet and the vertical wall of the lock in the one instance, and between the tunnel and floor of the lock in the other, were made. The vertical joints were made with tallow-dressed plaited spun yarn fastened to the timbers with canvas strips, and the horizontal joints by ½in rubber insertion bonded to the timber. The joints between the steel sections were made with ½in rubber insertion cemented to the steel flanges. The assembling and bolting up of the sections was carried out by divers.

The final sealing of the tunnel sections was effected by first placing close along the outside edges of the timber " sausages," 5in in diameter, made of puddled clay sewn into double thickness hessian strips. Finally, 18in wide strips of rubber insertion fastened to the outside of the oak timbers were laid over the " sausages " and on to the lock floor. The dewatering was effected by a 7in submersible pump and subsequent seepage was removed with a small hydraulic ejector.

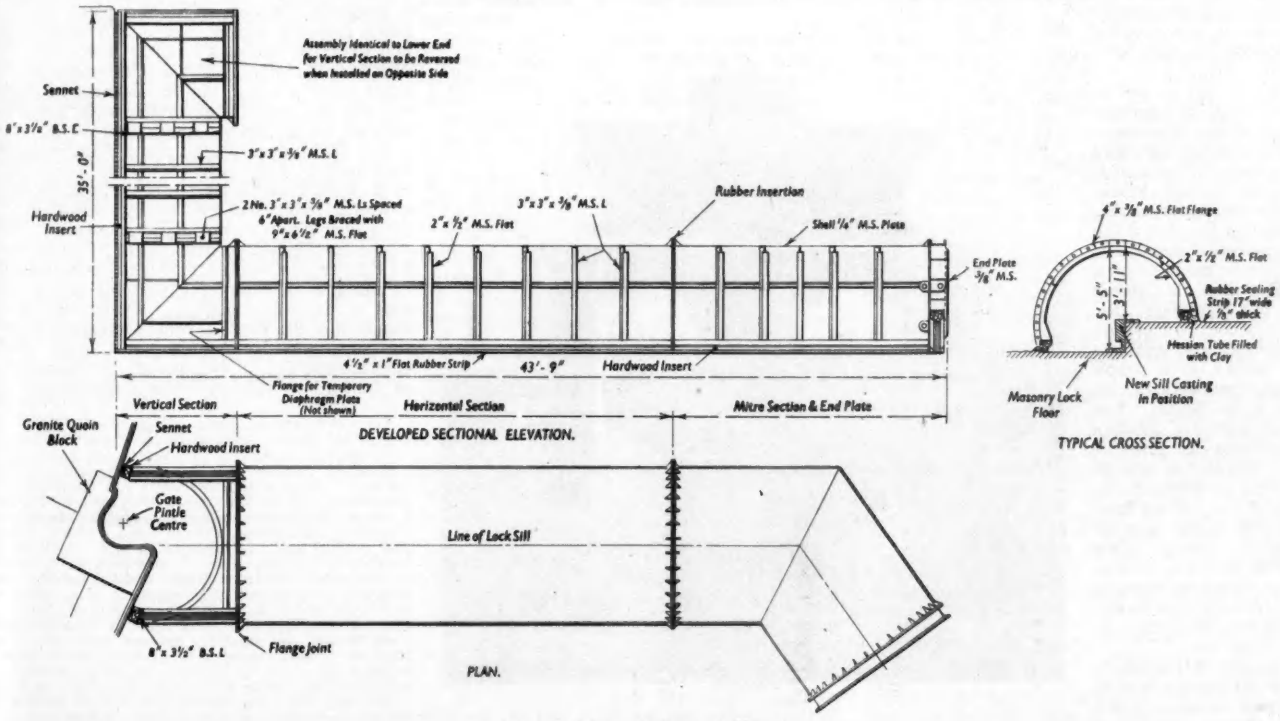
Inside the tunnel a small travelling cradle with three dimensional movement was used to handle the sill castings. The working height in the tunnel was 5ft 6in and the work entailed no discomfort.

The limpet and tunnel being at atmospheric pressure with no air lock, unhampered movement within them was possible, and the compressed air tools used for working inside prevented the air becoming foul.

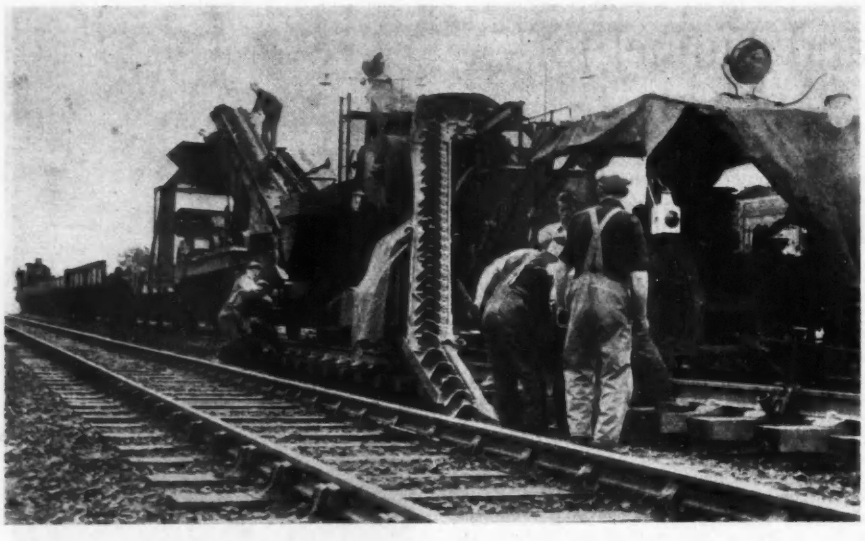
A heavy fender of steel framing faced with timber bolted to the lock side was used to protect the limpet. The dock was able to continue in operation during the work subject to a draught restriction at certain states of the tide. The



Limpet Dam Being Lowered into Position



Details of Limpet Dam and Tunnel



Intermediate Conveyor Discharging into Hopper

depth of water over the top of the tunnel varied from 28ft to 5ft. The civil engineering work, including the placing of the limpet, was carried out by W. and C. French, Ltd., under the direction of engineers of the Docks and Inland Waterways Executive. The photograph reproduced on page 279 shows the limpet dam, with the removable tunnel diaphragm in position, being lowered into place around the hollow quoin.

Ballast Cleaning on British Railways

EXPERIMENTS have been made on the North-Eastern Region of British Railways which aim at occupying only one track when using mechanical ballast cleaners. For some time now British Railways have been using mechanical ballast cleaners. They are self-propelled, rail-mounted machines consisting essentially of an endless chain bucket excavator operating ahead of itself and conveying the existing ballast from between and beneath the sleepers to screens which discharge the clean ballast into the 4ft behind the machine as it moves ahead and delivers the dirt thus separated, into wagons on an adjoining line. The machine travels over track from beneath which the ballast has been removed and the sleepers are therefore propped at intervals on temporary timber blocks.

If the dirt cannot be discharged on adjoining bank slopes, this operation has always involved possession of two tracks. In the present experiment the conveyor discharging the dirt drops its material on to a second conveyor mounted on a rail wagon, as shown by our engravings. The second conveyor, in turn, delivers the material into a hopper on a simple steel framework carried on a flat wagon. This framework is of sufficient headroom to permit a low mounted dumper to travel underneath it. The dirt is released from the top hopper into the dumper through drop doors and the dumper then travels the length of the train and tips the dirt into wagons standing on the same line.

Results of this experiment to date are said to be very encouraging and an output has been achieved approaching that obtained when screening into wagons on an adjoining road. This method is in use on French Railways where, instead of an intermediate conveyor between the ballast cleaner and the hopper, the conveyor of the ballast cleaning machine itself has a cranked horizontal extension over the hopper and the adoption of this modification is being considered for use on British Railways. These experiments were carried out under the direction of Mr. A. Dean, M.I.C.E., civil engineer, North-Eastern Region.

Water Supply at Glasgow

THE annual report of the chief engineer of Glasgow Water Department, for the year ended May 31, 1953, states that the year was one of considerable activity. The quantity of water supplied to the 90 square miles served by the undertaking averaged 86·1 m.g.d., a slight decrease over the previous year, in spite of the fact that a record number of 5977 new supplies were afforded during the year. Loch Katrine has not filled during the past fourteen months, due to low rainfall, and about 19in of rainfall, in addition to the amount needed to meet the normal draw-off, will be needed to fill the loch during the winter. Ten major contracts for capital works were placed during the year, and work started on seven of them, totalling £834,000. It is expected that the new west main will be completed before the end of this calendar year, with the exception of the Clyde water tunnel and its two approaches.

One of the new capital works recently authorised by the Glasgow Corporation consists of a water supply scheme costing approximately £219,000 to serve housing developments on ground which was brought within the city boundary in 1937, when ten areas in all were acquired at various points surrounding the previous boundary. One of the last of these areas to be developed for housing is in the east of the city, in what was formerly the county of Lanarkshire. The area is at present agricultural and the water supplies are provided by Lanark County Council and the Airdrie and Coatbridge Water Board, principally through very small mains to widely scattered farms and dwelling-houses. On about 1000 acres of this land Glasgow Corporation proposes to construct the Easterhouse Township. Water supply to the eastern area of the city has always been problematical owing to the high level of the ground and to its distance from the sources of supply, which lie principally to the north-west. Since the war, however, a new 36in diameter main has been laid from the service reservoirs at Milngavie, effecting a considerable improvement, as described in THE ENGINEER of April 28, 1950. This main skirts the east of the supply area and will form the eastern half of a ring main system. A quantity of 15 m.g.d. is pumped through this east main from the new pumping station at Buchley into several service reservoirs. Easterhouse Township will require about 3 m.g.d., and this supply will be taken from the new east main. A new reinforced concrete service reservoir of 3 m.g. capacity, divided in the centre, will be constructed at Garthamlock. It will have a top water level of 345ft A.O.D., which is the highest level to which water can be pumped from Buchley. A new pumping station at Garthamlock will be constructed and will pump water from this new reservoir to a water tower to be built on an adjacent site with a top water level of 463ft A.O.D. Considerable development is already taking place in the eastern area of the city and some housing schemes already started will be supplied from this new system. It is intended at present to construct only one-half of the reservoir and to install only one of an ultimate installation of four pumps, each capable of pumping 1 m.g.d. In the first place, the one pump only will deliver from a 24in main to be laid to supply the new reservoir direct into the distribution piping system at Garthamlock and other housing areas. As development proceeds and the half reservoir and water tower are constructed, two pumps will pump from the reservoir to the water tower, a third pump being installed for standby. Eventually, should the whole 1000 acres of the Easterhouse Township be developed, a fourth pump will be installed allowing for three operational pumps and one standby. The whole development is expected to be completed by 1959 and the works are designed to be capable of meeting all future requirements within the area of the city concerned. Design and construction of the works is being carried out under the supervision of Mr. S. D. Canvin, chief engineer and general manager of the Corporation of the City of Glasgow Water Department.

Dumper Truck Under Hopper

LAGGING ADHESIVE.—It has been announced that "Arabol" lagging adhesive which has been used in America for over ten years is now being made in England by the Arabol Manufacturing Company, Ltd., Wardrobe Chambers, 146a, Queen Victoria Street, London, E.C.4. The material was first produced to meet certain ship-building specifications, and is now used in factories, residential and similar buildings, as well as on ships and dockyard installations. This synthetic resin adhesive cement can be used for securing the covering on fibreglass, asbestos, magnesia and other kinds of insulation on pipes, boilers and ducts for hot and cold water and steam lines. It is claimed to be quick and easy to apply, resists high and low temperatures, withstands immersion and dries with a clean white finish that makes painting unnecessary. It is also stated to be vermin proof and suitable for outdoor as well as indoor installations and it has also been used for underwater lagging.

Developing the Managerial Abilities of Employees

By FRANCIS J. CURTIS*

This lecture was recently read before the Parliamentary and Scientific Committee. The author was unfortunately unable to attend through ill-health. It deals in particular with the methods adopted by the Monsanto Chemical Company in America to train and develop its employees for managerial posts.

Object

Before we get into the details of what to do and how to do it in the field of management development, let us pause for a moment and take a look at our object. As I see it, and I may be seeing it too simply, our object is a two-pronged one. From the standpoint of the firm or company, we are interested in having at our fingertips at all times a trained, timed reserve of managerial replacements, by which we mean a reserve calculated as nearly as humanly possible to be ready at the time it is needed. As managers ourselves, we must show an example and make sure that we are not caught with insoluble crises in our own field. From the man's standpoint, we are concerned with the development of his maximum capabilities which will give him, quite aside from the money reward, the greatest satisfaction in life. While we must not despise the value of monetary rewards, we must realise that they are only part of the story, and when we find a man to whom they are all in all, his value as a manager or as a man is immediately suspect. By the same token, we must see that non-monetary rewards are plentiful and that the desire for distinction, inherent in almost every man, is satisfied in so far as that is possible.

Our approach to this object must consider and take account of the desires and interests of both groups and not of either alone.

Method of Approach

When it is decided that a programme of executive development is necessary, the usual custom is to " install " a system carefully worked out by enthusiasts and imposed on both trainers and trainees without too much thought as to their real interest. I have a feeling that if the management could hear all the backroom comments, it would not be quite so sanguine of the success of its new effort. The need for and an enthusiasm for executive development training must be sold just like everything else. The availability of supply does not necessarily create demand.

The first step is obviously the preparation of a company inventory of positions and available replacements showing gaps or inadequacies. This is a very serious undertaking because upon the foundation of the inventory is to be built the whole structure of the programme. In so far as the foundation is wrong or weak, so will the programme be a failure or inadequate. It, therefore, cannot be overemphasised that here is the one place where slap-dash methods by men of action rather than of thought cannot be tolerated.

The second step is an equal inventory of the people to be trained and those who are to train them. Just putting a man to work alongside of or under a more experienced one does not necessarily give him training. Every company has in it individuals who may be called producers of men, who have a flair for the development of human beings as others have a talent for painting pictures, composing music, or getting out the goods. However, these individuals are somewhat rare and, therefore, every training programme must have as an essential part a section on training the trainers.

Furthermore, there is no use picking a man to be trained for management who simply does not want it, a situation which the framers of plans cannot usually conceive. Many men have other ideas of their object in life. Scientists, for instance, may much rather stick to scientific work than to push papers around. This is equally true of other specialised personnel. It is inefficient to start digging a well in the desert. Then there are other individuals who in one way or another have a set of characteristics which do not offer much promise for success in management. Some people are naturally one-man workers, others are self-centred. A chip on the shoulder rarely makes for harmony. The provision of enough potential managerial candidates from a character standpoint should always be in the minds of those concerned with personnel procurement. I have always felt that the criticism of procurement officers who follow this policy, namely, that they are trying to get all generals and no soldiers, falls down due to our inherent inability in the present state of the art to be at all certain whether a candidate is managerial timber or not. There will always, I think, be plenty of culls or plenty who will become culls to supply the soldiers. The yield of generals is unfortunately low. Above all, it should not be held as a black mark against those not chosen for management development, since quite often they admirably fill other places where perhaps the managerial candidate would not be so satisfactory.

Finally, no matter what system is set up, all detailed reports must be kept absolutely confidential in the hands of very few people. It is impossible to stop gossip at best and an overdose can ruin any system, no matter how well thought out and executed.

Specific Monsanto Plan

When it comes to talking about a specific rather than a general plan, most of us realise that aside from general principles, each set of factors demands individual treatment. Each one of us knows his own bailiwick. So, what I am going to describe to you is the plan developed for a decentralised organisation in the chemical industry where the top administration is carried out by a president and executive committee, with the individual divisions independent of each other, and headed by a general manager responsible for the functions of production, research, engineering, and sales, an organisation which is also served by a number of staff departments such as accounting, legal, medical, advertising, and so on. There is nothing about a centralised organisation (where all production is under one man, all sales under another, &c.), which says that it cannot be handled by the same methods, but such an organisation has not come within my experience, and whether one is better than the other does not happen to be our subject. I can see, however, that such a centralised organisation might be able to move more swiftly and certainly more uniformly depending upon orders rather than persuasion, and, at the same time, have a greater rigidity of programme less easily adaptable to local conditions and necessities.

In our organisation, therefore, the responsibility for carrying out training programmes is primarily in the hands of the division managers and the directors of the staff departments, co-ordinated by a manager of personnel development responsible for working out the operational details. In other words, under the philosophy of a decentralised organisation, the division managers and the staff directors are charged with the responsibility of seeing that they have sufficient and trained replacements coming along for positions which are likely to be opened. Obviously, the division managers have to delegate this work to their own plant managers, research directors, sales managers, and heads of engineering, and most of the larger plants have nominated a training director who works with these men and ties into the central personnel relations department.

One of the difficulties which immediately comes to mind in such an organisation is the transfer of capable personnel from one division to another, and I am willing to agree that this is not as easy as it may be in a centralised organisation. However, it can be done through the co-ordinating group which keeps all the records and which knows not only the personnel, but the vacancies which rise from time to time. It is an almost unheard of case where a division manager will not permit a transfer where a man can obviously better himself. Admittedly, they have to be sold, but it can be done.

The direct expenses of training are carried in the division or staff department budgets, although certain expenses are actively carried on outside the company or paid for out of the budget of the central personnel relations department.

Each year the division managers and staff department directors submit a report in February to the executive committee. In this report they summarise the personnel development activities, discuss the problems involved, and their plans for the future. Included also may be criticisms of the system at large and suggestions for its betterment. In this report are included brief individual analyses of their key employees, indicating strong and weak points and showing what is being done for their correction. This report also includes a new replacement schedule paralleling the original inventory, bringing a situation up to date. In addition, the executive committee discusses divisional development programmes at its regularly scheduled meetings with the general managers and department directors.

So much for organisation; now we come to methods and procedures. One of the most important of these is the periodic annual or semi-annual evaluation of all executive, administrative, supervisory and professional employees—trying as far as possible to have the opinion of at least two superiors in the chain of command. Since the subject of this talk is primarily concerned with managerial development, I may have given the impression that the programme deals only with that, so I would like to point out here that the system in practice includes training of some sort for all key employees whether they be following the managerial route or not. Naturally, the appraisals and criticisms vary, depending upon the type of employee. The research director is judged by different criteria than the man whose life work is to be in science or engineering activities alone.

Like others, we place a great deal of reliance on these periodic appraisals. Not only do they give the man a check on himself, since they are always discussed with the employee, but they also give him a chance to bring out his own ideas on almost any phase of the company's business. To talk about one's self is the most interesting subject in the world, and the provision of such an opportunity gives great satisfaction to almost any man. They force the superior to take a good hard look at the men working for him and may often inadvertently point out to himself some of his own inadequacies. Incidentally, it can be easily seen how important the work of the trainer is and how vital it is that he has the proper sympathetic approach to the problem.

In spite of all the difficulties which I have been mentioning, we still feel that the core of the system is on-the-job coaching rather than training by school methods. The thing we are trying to teach a man is to handle himself, to make his own judgments, to stand or fall by the actions which he himself takes. One cannot learn judgment out of a book. We all have acquired whatever we have by trial and error and a man in a class has no opportunity to practise this most difficult of arts. Certainly, many organisations have used classroom methods and their evidence is not to be summarily rejected. We have tried irresponsible training courses in the past and came to the conclusion that the time could be much better spent otherwise. An important part of on-the-job coaching is to keep the man well loaded up with work so that to a considerable extent he is straining for a goal and trying to do a little more than he thinks he can. In that way he grows.

In each plant or laboratory periodic meetings are held usually once a month with area groups, laboratory groups or in sales—product groups, attended by the plant manager or superintendents in the case of production, or the corresponding supervisory personnel in the other fields. Agenda are prepared by the training directors assisted with material from the central co-ordinating group. Problems, both of local and of general interest, are thrashed out.

Since these meetings contain all levels of supervision from foremen up to plant managers, they do serve as means of communication in both directions, but they are no substitute for day-to-day contacts between a man and his superior. There are always some individuals who shine in meetings and others who merely endure.

We believe also in a limited amount of job

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rotation. The reason we say limited is because people are not things, they cannot be lightly uprooted and shifted around too frequently. It has so happened that my company has been going through a considerable expansion and there have been many opportunities for shifting men not only between different functions such as production, sales, research, but also between different divisions and locations. Many men not yet thirty-five have worked in two or three different divisions and have been thereby broadened considerably. As is characteristic of a decentralised organisation, our different divisions, while they follow generalised company policies, differ a good deal in their handling of details and even in their organisation of divisional functions, all of which adds to the value of the experience obtained by a reasonable degree of transfers. Certainly, it is highly desirable that when a man reaches the point of being considered for a general managership, he shall have had experience in several of the disciplines by which the company's work is carried out. There is also the sticky problem as men get older and are receiving higher salaries of transferring into a department which for its own purposes could use a cheaper man. This is particularly true during periods of lower earnings where each department is trying to keep its expenses down. I have proposed that a special fund be set up in the personnel relations department to pay the difference in salary for a time between the man's actual compensation and what the receiving department would normally pay for the service rendered. So far, I admit, I have not been able to put this idea over, but I still think it is a good one.

All companies, from time to time, set up committees to study certain operational problems—a process now dignified by the title of Operations Research. Here is an obvious opportunity for younger men to get their teeth into managerial problems and such a committee should be headed by experienced personnel who permit the younger ones to do all the work. Some of these committees are semi-permanent as many of our divisions have periodic meetings of personnel chosen from production, research, sales and engineering who bring to the problems the experiences of their various activities. For instance, we have a "housekeeping" contest yearly, in which a group of men picked from the various divisions is sent around visiting the plants and marking them for the efficiency of their housekeeping, safety programmes, and so on. As a result, a prize is given each year which is highly thought of and for which the competition is very keen. This opens up a wonderful opportunity for every man who is being trained for higher positions to see and judge the company at large.

We have always been in favour of a considerable degree of attendance at the meetings of various societies, technical or otherwise. There is a more or less regular system of rotation for sending men to technical meetings at company expense and of giving them the time to go, offbeat, if they wish to pay their own expenses. When we first started this policy, it so happened that a chemical society meeting took place in Chicago, whereupon practically the whole personnel of our Central Research Laboratory at Dayton, Ohio, packed into cars and went off, leaving the laboratory flat. Naturally, a ruling had to be made requiring permission of the director. Liberality can degenerate into licence. Personnel other than technical have their own groups which are handled similarly.

For a number of years, we have had a system of leaves of absence for chosen technical employees to return to a university of their own choice for a year's graduate work, during which time they are paid full salary and travelling expenses for themselves and family. Here, again, the boys tried to put one over. Soon they were choosing Oxford and Cambridge to get a trip abroad at company expense. We cured that one by confining the choice to North America. Likewise, we send four men a year from the upper executive group to the Harvard Advanced Management Program. The experience here has, on the whole, been good, though some have found it difficult to adjust to schooling. Most have felt the course very worth-while, particularly the bull sessions. There are continually cropping up throughout the company individual courses, particularly among the technical men, on specific subjects often given by one of their own number, but sometimes by trainers brought in from the outside.

You can see that consonant with our philosophy of decentralisation, we do not have a rigid plan, but one which is flexible and can be changed to suit time and circumstances. Some of our divisions use outside counsellors and consultants; some send their men to consulting firms for analysis. We believe in giving them a great deal of freedom in this respect, because any techniques which are developed and proved to be of value can be incorporated in overall company programmes later. We have long toyed with the idea of setting up internal counsellors at each plant to whom key employees could go with their problems. There are many advantages to this proposal, as the relationship of superior and inferior is not one conducive to many confidences, whereas, it is often felt that a man may talk more freely with a sympathising person who is not his own superior. However, looking at the matter from another angle, it is likely that such a programme might be quite disruptive of organisation, and it might even be confusing to the individual who cannot conclude who has the most weight in deciding his career. So far the balance seems to be on the negative side, part of which is due to the difficulty of finding such individuals.

Another reason for a flexible system is that it is quite obvious that training for research involves differences from production supervision, and that for salesmen differs from both. Hence, we have followed the plan of outlining organisation and general principles and leaving the details to be filled in by the divisional organisations and the central co-ordinating department.

May I come back once more to the importance of the attitude of those who are doing the training? One of the most important components of their attitude will be the degree of support given to the programme by the top executives of the company. Once you can convince a man that in the eyes of the high executives of the company his value and advancement will be judged, at least in part, by the kind of men he produces, you will have little difficulty in getting the kind of action you want. Maybe this is in the carrot-in-front-of-the-nose class, but I am afraid altruism is rarer in the human race than it should be. I have a feeling that these principles have not been stressed sufficiently or often enough and their better observance will conduce towards a better operating programme.

Conclusion

We can claim no great degree of originality for this programme. It has been developed by ideas obtained wherever we could. It will be changed as seems needed and as often as appears desirable. In other words, please do not accept this as sacrosanct and a final word. It seems to me that most of the principles of training now seem to be well developed, the main basic argument being the one between training of the school type or by the on-the-job system.

Our chemical industry in the United States has undergone, and is still undergoing, a tremendous expansion, expected to be an overall 55 per cent by 1955 over what it was in 1951. We can no longer depend on sink-or-swim methods of finding executives. We must get the highest possible yield from our recruits. We must help them over the humps so that they can realise their best possibilities and, in turn, they must let us. Only in this way can we supply this expanding industry with its scarcest component—top-grade managers.

British Car Production.—The rate of car production in British factories has again broken all previous records in July with an all-time peak weekly average of 13,200 units, almost five cars a minute during the working period. Output of commercial vehicles, nearly 4600 a week, was slightly more than the average for the previous three months. Another big advance in car exports brought the July shipments above 32,000, dwarfing the February figure, six months previously, by almost 12,000 models. Compared with June, there was an increase of 3000 cars exported to Australia. Exports of commercial vehicles, 11,400, were the highest since May, 1952, and nearly 3000 more than in June last. Agricultural tractor shipments numbered just on 7000.

Indian Engineering News

(By Our Indian Correspondent)

Nationalisation of Airlines

Acting on the recommendation of the Air Transport Inquiry Committee Report, 1950, the Government of India took over on August 1st, all the internal and external airlines which, from that date, are being managed by two corporations, namely, the Indian Airlines for the domestic services, and the Air-India International for the foreign services. Among the reasons that have been advanced in favour of nationalisation are: too many air operators than were warranted for the country's requirements; too many aeroplanes, far in excess of present needs; duplication and overlapping of existing routes; paucity of both additional and adequate traffic potentiality; inadequacy of unexplored or untapped new routes, both in India and the neighbouring countries; lack of general prosperity amongst the travelling public, and the continual incurrence of heavy losses by the operators. The two corporations are very much on the lines of B.O.A.C. and B.E.A., and most of the private operators are among the members of the new boards, the chairman of the Air-India International being Mr. J. R. D. Tata, a pioneer in air transport, and the head of the well-known industrial enterprise of Tatas.

The authorised and paid-up capital of the nine air transport operators, operating both on internal and external routes, amount to £16,000,000 and £5,000,000 respectively, and the industry employs between 9000 and 10,000 employees in all throughout India. The airlines have a fleet of 110 aircraft, of which there are ninety-one twin-engined, twenty-one-seater "Dakotas; twelve twin-engined, twenty-seven-seater "Vikings"; three four-engined, fifty-six-seater "Skymasters," and four four-engined, forty-four-seater, fully pressurised "Constellations." The actual number of aircraft required to operate services on the present scale, however, is about fifty, and the Government is devising ways and means of disposing the surplus of sixty aircraft either by pressing them into service with the Indian Air Force, or, what is more likely, by selling them abroad. The total route-mileage of air services was 27,763 miles, of which just over a half was domestic and the rest international. In the year ended June, 1952, the services flew 19,538,427 miles, carried 438,103 passengers, 7,720,788 lb of mail, 83,497,499 lb of air freight, and 4,532,730 lb of newspapers. The total capacity was 57,620,719 ton-miles. Although, however, a few of the bigger airlines showed a profit, the net loss was of the order of £250,000. It is estimated that the new integration under the State auspices will result in a profit of about £300,000, the total cost of State operations being £4·5 million, about £500,000 less than the present cost.

Although the Government is taking over the existing airlines at a total cost of £3·3 million, the Planning Commission has estimated a cost of £7·9 million for the replacement of air fleet with a view to modernising the services by providing bigger, better, more comfortable and economic aircraft. It is proposed to expand the existing international routes and fifteen additional aircraft, costing about £4·5 million, will be needed. In addition, five more aircraft are required to be operated on the West-bound services to Europe, costing £3·4 million. Of these, two multi-engined "Super-Constellations" have already been ordered, and three "DC-6" aircraft are expected to be ordered very soon. When two "Comet" jet liners, Mark III, join the fleet in 1957, the total additional aircraft will be twenty-two, and the cost nearly £10,000,000.

The Five-Year Plan envisages a capital expenditure of £7·25 million for a period covering three years from 1953 to 1956 for development and improvement of civil aviation projects, other than operation of air transport industry. About £5,000,000 will be spent on the construction of new runways, hangars, workshops and administrative and air traffic buildings. There are at present 305 aerodromes in India, of which fourteen are private and the rest owned and managed by the Government. They yield an annual revenue of about £400,000. Plans are also afoot for the provision of communication

and navigational aids and modernising of ground facilities for night flying such as runway lighting, provision of red beacons, installation of various modern instrument flying and landing systems, and perfection of the existing meteorological facilities. This is expected to cost £2·25 million. The total capital expenditure on the expansion of airlines in the coming three years will thus amount to about £17,000,000, most of which will be spent outside India mainly on the purchase of aircraft and modern aerodrome installations.

Engineering Industry

Although the progress of the Five-Year Plan, according to a Government notification, has not been up to schedule in such spheres as irrigation and hydro-electric projects, it has maintained its tempo in engineering industries, as is clear from the number of new production ventures started last year and the several new products manufactured for the first time in the country. The new products include bicycle spokes; card and gill pins; duplicators (power operated); fluorescent tubes; grey iron cylinder blocks for automobile engines; grinders for cement industry; industrial boilers; industrial sewing machines; interlock knitting machines; machine tools, including wood planing machine, 12in/4in, and power presses, all geared, 40 tons capacity; non-ferrous metals, including flat products of 38 and 57 S aluminium alloys; pick-up heads for radio-gramophones; pistons; radio components, such as loudspeakers and potentiometers and band-changing switches; small tools, including ground thread and relieved taps, adjustable reamers, tangential and Coventry diehead chasers; surveying and mathematical instruments (pilot models for manufacture of theodolites, planimeters and nautical sextants), and water meters. In addition to these manufacture of new ranges has been established in the following items:—Power and distribution transformers of 2000kVA capacity; slip-ring motors up to 100 h.p.; scroll chucks of 10in and 12in capacity; ball bearings up to 2in bore, and drill chucks of $\frac{1}{16}$in to $\frac{1}{2}$in diameter.

Among the new ventures, textile machinery and automobile components deserve mention. A Calcutta firm, in co-operation with a British firm, has started manufacturing Lancashire boilers and the plant which began production in March this year has a capacity of twenty boilers per annum. Another Calcutta firm has made a proposal for the manufacture of hosiery needles which has been approved and production is expected to begin this year with a capacity of 10,000 needles per day of eight working hours. In Madras, two factories are expected to go into production this year, both with an initial capacity of about 100,000 sparking plugs per year to be raised eventually to 500,000. One is receiving technical assistance from a British firm and the other from a German firm. Manufacture of electric horns is expected to be started in Madras this year in a plant of a capacity of 6000 horns per year. A German firm is also assisting in the installation of a factory for making fuel injection equipment for diesel engines in Madras.

With a view to assisting further the engineering industry, the Government has appointed a strong committee charged with the task of a preliminary survey of the capacity lying idle in the industry and the degree to which rationalisation of production is possible within the existing production framework. The Government has also promised additional export facilities as many of the new products are finding their way into export markets, mainly in the Middle East and South Asia.

Rubble Masonry and Mass Concrete Dams

Over a hundred dams, large and small, are at present under construction all over India, most of them of masonry, earth-fill or rock-fill and a few of mass concrete, the selection being dependent on various factors such as suitability of site, speed of construction, availability of materials and cost. Concrete dams have only recently appeared on the Indian scene, the first one to be completed so far being the 90ft high Tilaiya dam of the Damodar Valley project. Roughly speaking, of the new dams under construction, those in the south are in rubble masonry and those in the north either in concrete or earth-fill. The Periyar, the Krishnaraj Sagar, the Mettur and the Tambrapani dams are outstanding examples of completed rubble masonry dams in South India to which the Tungabhadra dam is expected to be added very soon. All these dams are of medium height, and the cost of the rubble masonry in them is much lower than that of mass concrete, had this material been substituted for the former. The labour, too, is cheap and freely available and is highly skilled in such construction.

However, even in places where there is a tradition of rubble masonry construction, it may not always turn out to be cheaper than mass concrete. A number of factors militate against the selection of rubble masonry such as the restriction of space and consequent lack of speed in construction. In Travancore-Cochin, a masonry dam and a mass concrete dam are being constructed simultaneously at sites about 15 miles distant from each other, and a comparison of the cost shows that there is very little difference between the two.

A comparative analysis has also been made in the case of the Poringalkuthu dam in the same state, and the conclusion appears to be that even though the unit cost of rubble masonry is lower than that of mass concrete, the latter is more economical when the overall picture is taken into consideration.* The dam, which is a part of the second-stage development of the Poringalkuthu hydro-electric project, will be about 250ft in height, involving about 650,000 cubic yards of concrete. On the basis of the cost of another dam now being built nearby, the cost of mass concrete would be about Rs. 40 (60s.) per cubic yard, or approximately Rs. 150 per 100 cubic feet (£11·25), including the proportionate debit of the tools and plant required for the concrete. This would work out to Rs. 2·6 crores for the mass concrete, and as the period required for placing the concrete is estimated to be 1000 days, or four years, the total cost, including interest charges at 4 per cent, would be Rs. 2·8 crores (£2·1 million).

The cost of rubble masonry would be Rs. 35 (52s. 6d.) per cubic yard, or about Rs. 130 (£9·75) per 100 cubic feet, which works out at Rs. 2·3 crores for the masonry required for the dam. The daily output that can be expected is 10,000 cubic feet per day, owing to restriction of space. Thus, it would take about seven years to complete the masonry, and the total period required for the completion of the dam would be nine years. As the construction of the tunnel, supply and erection of the penstocks, construction of the power-house and supply and erection of the machines could be completed without difficulty in six years, the delay in completion of the dam would materially affect the economy of the scheme. Taking this into account, the total cost of the rubble masonry on the dam would then be about Rs. 3·2 crores (£2·4 million)—that is, about 14 per cent more than that of mass concrete. This result is expected to alter substantially the prevailing view that rubble masonry is almost always cheaper than mass concrete. Tables I and II give the data from which the costs have been computed.

TABLE I—*Cost of Mass Concrete for the Poringalkuthu Dam*

Item	Unit	Rate (shillings)	Quantity per cu yd	Cost per cu yd (shillings)
Cement	Ton	105	0·15	15·75
Transport	Ton	15	0·15	2·25
Surki (powdered brick)	Ton	30	0·03	0·9
Transport	Ton	15	0·03	0·45
Sand	Ton	4·5	0·45	2·075
Transport	Ton	9	0·45	4·05
Coarse aggregates	Ton	9	1·07	9·63
Mixing and placing concrete	Cu yd	5·25	1·00	5·25
Shuttering	Sq yd	1·5	1·00	1·5
Tools and Plant (including repairs, &c.)	—	—	—	16·5
			Total	58·305
			Contingency	1·695
				60·00

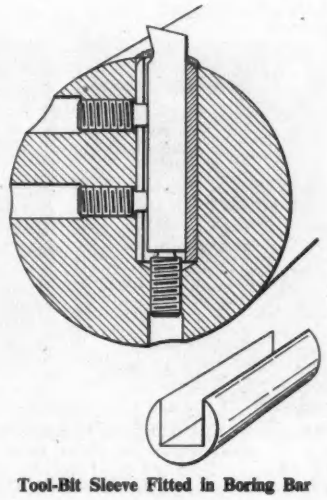
TABLE II—*Cost of Rubble Masonry for the Poringalkuthu Dam*

Item	Unit	Rate (shillings)	Quantity per cu yd	Cost per cu yd (shillings)
Cement	Ton	105	0·09	9·45
Transport	Ton	15	0·09	1·35
Surki (powdered brick)	Ton	30	0·02	0·06
Transport	Ton	15	0·02	0·3
Sand	Ton	4·5	0·43	1·95
Transport	Ton	9	0·43	3·9
Stones at site	100 cu ft	22·5	25·60	5·85
Face stones	Cu ft	4·5	1·4	6·3
Pointing	100 sq ft	30	1·0	0·3
Labour	10 cu ft	4·5	27·00	12·15
Tools and Plant (including repairs, &c.)	—	—	—	9·00
			Total	51·15
			Contingency	1·35
				52·50

Boring Bar Tool Bit Sleeves

A USEFUL component is now being made by W. H. Marley and Co., Ltd., 105, High Road, London, N.11, to eliminate the need for machine accurate square holes in boring bars to accommodate tool bits. The component consists essentially of a round sleeve with a deep square slot cut down its length, and its method of application can be seen in the diagram below.

To apply the sleeve the boring bar is simply drilled and reamed to depth at the required point to take the appropriate sleeve, which can then be pressed in and fixed by pinning or brazing. At its blind end the hole is drilled with a smaller hole which is tapped to take a bit-adjusting screw. One or more holes drilled at right angles to the sleeve slot are tapped to take fixing screws for the tool bits. To obtain the necessary tool rake angle without need for excessive grinding



Tool-Bit Sleeve Fitted in Boring Bar

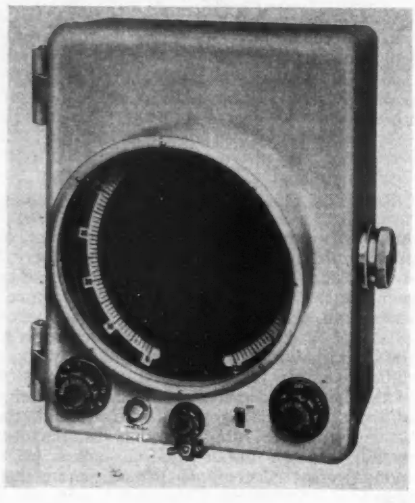
* George Oommen, "Suitability of Mass Concrete for Dams in India," *Indian Concrete Journal*, June, 1953.

the sleeve hole can be drilled off-centre to the boring bar, so that normal grinding will give the required cutting angle.

The sleeves are made in six diameters to suit tool bits from $\frac{1}{16}$in to $\frac{3}{8}$in square, and each diameter is made in three lengths.

Echometer for Coastal Waters

A NEW visual-indicating design of echometer, which has been given the name of "Visette" and which is illustrated herewith, has been produced recently by the Marconi International Marine Communication Company, Ltd. This echometer is being produced by the company



"Visette" Echometer

primarily to meet the requirements of coastal and estuary navigation and of fishing craft which, when working, do not require soundings outside the 100 fathom mark.

The instrument has been designed to have a range of 0 to 130 fathoms, and the depth of water is indicated at the correct reading by a bright red flash of light on a continuous circular scale. A hood fitted with a "Perspex" window set at an angle shades the face of the instrument and eliminates any outside reflections which confuse the observer in bright daylight or artificial light. This arrangement, combined with the brightness of the flash indicating the sounding, makes for easy reading of the "Visette" from any position in the wheelhouse or chart room.

Space is at a premium on the bridge of a coastal or fishing vessel, so, with this in mind, the company's designers have made the "Visette" completely self-contained, the indicator mechanism, transmitter, receiver and power unit all being arranged to fit into a cast alloy case measuring 16in wide by 18in high by 14in deep. The case is designed for bulkhead mounting on anti-vibration brackets and the front panel is hinged in the form of a door, while the various chassis units inside are also hinged so as to provide easy access for the purpose of inspection and maintenance.

A 24V d.c. supply obtainable either from batteries or through a rotary converter, from the ship's mains, is required to operate the instrument, which has a total power consumption of only 20W, and thus can be operated for long periods without undue battery drain. Directly heated valves reduce the warming-up period to a minimum so that it is possible to obtain readings within three seconds after the echometer has been switched on. Two models are available, that calibrated in fathoms giving soundings at the rate of 163 per minute, while the version reading depths in metres gives soundings at 160 per minute.

Echometer Interior

Infra-Red Heating Units for Farm Stock

MODERN methods of rearing pigs, poultry and other farm stock include the application of infra-red heating, and for this purpose two new units have been introduced recently by the

Single Lamp Infra-Red Heater

General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. They are a 250W bright-emitter heater and a 300W dull-emitter unit, the former employing a lamp as a source of heat and the latter a metal-sheathed element.

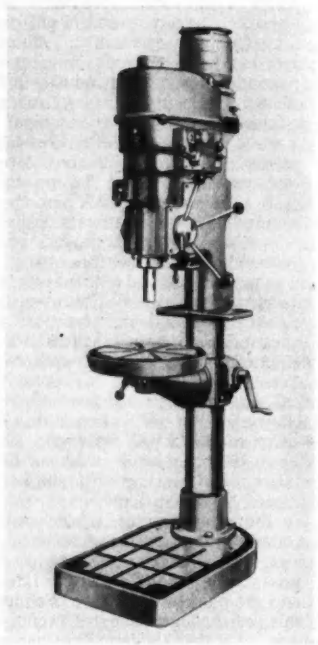
The single-lamp heater, which is illustrated herewith, incorporates a 250W, 200/260V "Osram" infra-red reflector lamp. The interior of the upper part of the bulb is silvered to provide a reflector for projecting the heat downwards, the end of the bulb being lightly obscured to diffuse the heat. The cap is mechanically attached to the bulb to prevent it from becoming loose under arduous service conditions, and the brass shoulder ring is electrically insulated from the cap to prevent accidental contact with live metal. A sheet steel shroud protects the lamp from mechanical damage and from dripping moisture, and the lamp-holder and connections are adequately shielded to prevent accidental contact.

The 300W dull-emitter heater is mounted in a substantial aluminium reflector, there being ample protection for all the live metal parts. The metal-sheathed wire element is claimed to be "practically unbreakable."

A Pillar Drilling Machine

IN the photograph we reproduce below there can be seen a new pillar drill which is now being made by Kerry's (Great Britain), Ltd., Warton Road, London, E.15. It has a maximum capacity of 1¼in in mild steel and 1½in in cast iron.

The new machine has a strongly webbed base with a machined tee-slotted surface on which work can be bolted. Its 6½in machined column is fitted with a rack for table height adjustment, and on it the table can be swung completely clear when using the base for work supporting. The table, which can be



1½in Pillar Drilling Machine

raised and lowered through a handle-operated worm and rack gear, can be rotated through a full circle or swivelled up to 90 deg. each way for angular drilling of components. The maximum distance from the spindle to the base is 43in and from the spindle to the table is 25in.

The drill head is driven by a 2 h.p., 1440 r.p.m., flange-mounted motor, and in it all the gearing is totally enclosed. Three spindle speed ranges are available from 55 to 167, from 167 to 500, and from 480 to 1440 r.p.m., and in each of these ranges the speed is infinitely variable. Spindle speed is shown by an arrow on a chart on the right-hand side of the drill head.

The three power feeds available are 0·004in, 0·008in and 0·016in per revolution of the spindle. These feed speeds are selected by means of a lever, and a single lever control for power feeding is conveniently situated adjacent to a graduated depth stop drum on the left-hand side of the head. A starwheel used for hand feeding traverses the spindle directly, and for fine hand feeding a small handwheel situated underneath the head can be used.

CONFERENCE ON HARDNESS TESTING.—The Sheet and Strip Metal Users' Technical Association is to hold a conference on "The Hardness Testing of Steel" at the City Hall, Sheffield, on Wednesday, Thursday and Friday, October 14th, 15th and 16th. In addition to a series of papers by authors from this country and overseas, an exhibition of hardness testing equipment is to be staged during the period of the conference. Full details of the conference and exhibition are available from the honorary secretary of the Sheet and Strip Metal Users' Technical Association, Mr. Alastair McLeod, 49, Wellington Street, London, W.C.2.

Industrial and Labour Notes

British Overseas Trade

The final figures of the United Kingdom's overseas trade in July confirm that the value of exports was £234,400,000, which was £24,400,000 above the monthly average for the second quarter of this year. The Board of Trade says that the increase in the value of exports in July was accounted for mainly by the longer working month, there being twenty-seven working days compared with an average of twenty-four in the preceding three months. Taking the four months, April to July, together, however, and bearing in mind the fact of public holidays in April, May and June, exports were nearly 5 per cent above the average for the year April, 1952, to March, 1953, in which period the full effect was felt of import restrictions imposed in some important sterling markets.

Most of the improvement in July was in exports of manufactured goods, nearly all groups showing an increase over the second quarter average. Exports of engineering products increased by £7,000,000 (of which the vehicles group accounted for £4,000,000), textiles by £5,000,000, metals by £3,000,000, and other manufactures by £6,000,000. In engineering manufactures, exports of motor-cars increased from a monthly average of 25,731, valued at £9,000,000, in the second quarter, to 27,741, valued at £10,000,000, in July. Motor-car exports to the U.S.A. and Canada declined in July, but those to Australia, New Zealand, South Africa and Sweden all increased. Exports of aircraft and parts, which rose to a monthly average of £5,900,000 in the second quarter, increased further in July to £6,800,000. Machinery exports, which had increased slightly between the first and second quarters, showed a further rise of 6 per cent in July, largely as a result of increased exports of electrical machinery and mechanical handling equipment. Exports of electrical goods and apparatus, which declined by £500,000 a month between the first and second quarters of this year, rose in July to a value of £10,000,000, and were 4 per cent above last year's monthly average. It is stated that the recovery was most marked in exports of telegraph and telephone cables, the value of which was over £1,000,000 in July. Exports of metals in July were valued at £27,000,000, which was £3,000,000 above the monthly average in the second quarter. Exports of iron and steel to British East and West Africa, the Netherlands and the U.S.A., all showed substantial increases over the second quarter's average.

Area Pattern of British Trade

In the current issue of the *Board of Trade Journal*, some particulars are given of the area pattern of United Kingdom trade in the first half of this year. In that period the monthly average value of exports was £209 million, compared with £213 million in the final quarter of last year, and £215 million for last year as a whole. The volume of exports was 5 per cent lower in the first half of this year than in the corresponding period of last year, but 5 per cent greater than in the second half of 1952. The Board of Trade says that an encouraging factor in the figures for the second quarter of this year was the high level of exports to North America. Imports in the first half of this year averaged £282 million a month, compared with £263 million in the preceding six months, the volume of imports in the first half of this year being greater than in either half of 1952.

It is stated that practically the whole of the rise in the value of United Kingdom exports in the first half of this year, compared with the preceding six months, was in exports to the sterling area. United Kingdom exports to the non-sterling world as a whole in the first half of this year remained at about the same level as in each half of 1952, but a rise in the exports to O.E.E.C. countries and their possessions was more than offset by a continuing fall in exports to the rest of the non-sterling non-dollar world. The increase in United Kingdom exports to the dollar area between the two halves of 1952 was continued in the first half of this year on a reduced scale which, however, concealed substantial rises in exports of metals and engineering products in April, May and June. These, the Board of Trade says, resulted mainly from a seasonal recovery in exports to Canada of iron and steel manufactures, machine tools and motor-cars.

United Kingdom exports to the sterling area, which, in the second half of 1952, had declined to 18 per cent below the level of the first half, recovered in the first six months of this year to 5 per cent above the level of the latter half of 1952. The rising trend was apparent in nearly every group of manufactures, and was particularly evident in the metals and engineering groups. Exports of iron and steel and their manufactures and of electrical goods recovered to a level slightly above that of the first half of 1952. The value of machinery exports to the Union of South Africa, which had decreased a little between the two halves of 1952, recovered in the first half of this year to a level 9 per cent above that of the corresponding period of last year; vehicle exports, by value, to South Africa were 20 per cent above the level of the first six months of 1952.

The T.U.C. General Council's Report

The annual report of the general council of the Trades Union Congress has been published this week. It is to be submitted to the Trades Union Congress, which begins at Douglas, Isle of Man, on September 7th.

There are, of course, several passages in the report which deal with productivity and industrial efficiency. It is commented that since last year's congress, the pattern of this country's economic problems has not undergone any basic change. The nation is still faced, the report states, with the compelling need to pay its way in a world where competition for markets grows fiercer and where high industrial efficiency is essential for survival.

The report goes on to record that the general council of the T.U.C. has taken a leading part in the creation and the activities of the British Productivity Council. The general council, it is claimed, has tried to help the trade union movement to shoulder new responsibilities and to fit itself for constructive contributions to higher industrial efficiency. But, the report continues, the general council would have been happier if the Government, in the 1953 Budget, had on its part given some indication "that it was preparing to play a positive and vigorous role in overcoming the difficulties facing the nation." The improvement in the balance of payments, the general council contends, has been largely owing to temporary factors such as import cuts and improved terms of trade and not to the more controversial aspects of Government economic policy. Furthermore, the report observes, "trade unionists see the Acts to take road haulage and iron and steel out of public control as retrograde steps not calculated to improve the working of the nation's economy."

On Wednesday morning a separate report was issued by the T.U.C. setting out the general council's views as to how public ownership and control can assist the national economy. It will be recalled that at last year's congress a motion was passed calling for the extension of "social ownership" and the "democratisation of the nationalised industries."

United Nations Technical Assistance Programme

The United Nations economic and social council has recently held a session in Geneva, during which there was some discussion of the "expanded programme of technical assistance." A statement issued this week by United Nations says that one of the misconceptions about this programme is the assumption that it may supplant the national programmes of economic development of those countries to which assistance is given. The statement makes it plain that the preparation of national plans of economic development is a task for individual governments. The international agencies can use their technical assistance resources to help countries to formulate and implement their own integrated plans, but the plans themselves must be the responsibility of the governments concerned.

The statement goes on to point out that, in the majority of projects, the United Nations technical assistance programme requires lengthy periods to make its plans effective. In valley development, for example, many years must sometimes elapse before dams and barrages are erected and irrigation schemes completed. The idea of a long-term programme, as opposed to short-term developments, was emphasised at the meeting of the economic and social council, particular reference being made to the difficulties of financing the programme on the basis of a one-year budget. It was suggested that the member countries might be persuaded in future to pledge their contributions for longer periods than a year and thus enable the United Nations' technical assistance programme to be consistent with its original idea—that of a long-term undertaking.

The Iron and Steel Corporation

The Iron and Steel Corporation of Great Britain ceased to exist on August 13th, one month after the "appointed day," under the provisions of the Iron and Steel Act, 1953. The Corporation's final accounts, covering the period October 1, 1952, to July 12, 1953, were published last week. These accounts are concerned solely with the Corporation's finances; they do not relate to the trading, nor do they reflect the results of the activities in the period covered, of the companies which were publicly owned under the Iron and Steel Act, 1949. The income of the Corporation in the nine months or so to which the accounts relate is shown as £4,192,379. It represents dividends received on the share capital of the Corporation's subsidiary companies, together with interest on loan capital accruing during the period. The unappropriated surplus on July 12th was £720,989. One item in the accounts shows that the Finance Corporation for Industry was paid £2,250,000 as compensation under the 1949 Act for loss of option rights to acquire securities in companies which became publicly owned on February 12, 1951.

An Industrial Supervisors' Conference

The August issue of the *Journal* of the Institute of Industrial Supervisors gives notes on a week-end conference for supervisors held at the Horséley Towers Training Establishment in July. The conference was opened by Mr. R. H. Coates, who spoke of the need for foremen to adjust themselves to rapidly changing times, and Colonel Ratcliffe, the secretary of the Management Research Association, then spoke on the subject of leadership. In dealing with the subject of communications in industry, the next speaker, Mr. R. F. Banister, suggested that natural working groups of about twelve members should be provided with a first-class leader. Otherwise, he said, unofficial leaders possibly hostile to management might arise and influence group opinion. Each group leader at every level of management had to play the difficult role of leader of his own group and subordinate in the next senior group, and supervisors especially needed help in reconciling these two roles. The conference then reached the conclusion that, whilst joint consultation was a necessary and wholesome part of the organisation of every industrial concern, it could not possibly provide a means by which anything like the fullest amount of information could be conveyed. The only way of providing everyone in a concern with all the information they needed to do their work properly was through the existing chain of management. This chain needed strengthening by sufficient consultation between seniors and subordinates at each level.

Notes and Memoranda

Rail and Road

WINTER TRAIN SERVICES.—British Railways announces that it is proposed to introduce further improvements in the winter timetables which will operate from September 21st next. Compared with last winter, 126 trains are being speeded up by from ten to sixty minutes; many of the accelerated summer schedules are being retained throughout the winter. The 11.45 a.m. train from Bristol to Paddington will be accelerated by ten minutes and will cover the 117¼ miles in two hours; the two-hour service between London and Birmingham will also be extended to the Western Region route with the 9 a.m. from Paddington, and the 9 a.m. from Birmingham, Snow Hill. Altogether, twenty-seven start-to-stop timings at 60 m.p.h. or over will operate on British Railways this winter compared with three last winter. The number of sleeping-car services each week will be 384, compared with 379 last winter, and nearly half the third-class sleeping-cars will be of the new design with two berths to a compartment.

Air and Water

ROYAL TOUR LINER.—The Shaw, Savill and Albion liner "Gothic" is expected to arrive at Birkenhead shortly to be prepared by Cammell Laird and Co., Ltd., for the Royal tour of the Commonwealth.

ENGINEER COMMODORE.—The Clan Line has created the post of engineer commodore and has appointed Mr. T. L. Main, the chief engineer of the company's "Clan Macdougal," to be the first engineer commodore of the fleet.

CARGO HANDLING.—We are informed by the International Cargo Handling Co-ordination Association that the port of New York has joined the association, to bring the total number of port members to fifty-five, and that a United States National Committee has been formed.

Miscellanea

ROLLING MILL FOR SWEDEN.—According to *The Anglo-Swedish Review*, the Sandvik Steel Works, Sweden, are to erect a new rolling mill having an annual capacity of 100,000 tons. The mill, which is to have a length of 460ft and a width of 230ft, will handle ingots weighing up to 4½ tons.

THE LATE MR. A. PEAKE-JONES.—We record with regret the death of Mr. Arthur Peake-Jones, which occurred at his home on Friday, August 14th. Mr. Jones, who was sixty-eight years of age at the time of his death, had been advertising manager to the British Tyre and Rubber Company, Ltd., since 1931.

BLAST-FURNACES IN HUNGARY.—The first blast-furnace at the Stalin iron and steel works—which are being built on the Danube 40 miles below Budapest—was blown in on August 20th. It is reported that a second blast-furnace will be completed next year, by which time four open-hearth steel melting furnaces will be operating.

NORWEGIAN COPPER.—It has been reported by *The Anglo-Swedish Review* that the Swedish Boliden Mining Company has asked the Norwegian Government for a long-term concession to mine copper in Norway. The proposed mining area covers 400 square miles around Kautokieno in the inner highlands of Finnmark, Northern Norway.

CARE OF BUILDERS' MACHINES.—The latest of the Ministry of Works' advisory leaflets has the above title, and is concerned with the maintenance of builders' plant. It is pointed out that a regular maintenance routine, for the small building contractor who cannot carry a repair organisation, can be of considerable value in preventing breakdowns and getting the best out of plant. Copies of the leaflet (No. 33) may be obtained from H.M. Stationery Office, price 3d.

PLASTIC EMULSION PAINTS.—We are informed by Allweather Paints, Ltd., 36, Great Queen Street, London, W.C.2, that in addition to its chlorinated rubber paints, it is now making a plastic emulsion paint known as "Nic-o-Loid." This emulsion paint resists condensation, dries without brush marks and can be applied equally well to almost all wall surfaces, including those of new plaster, cement and asbestos. It is supplied in twenty-seven standard shades and 1 gallon will cover an area of about 8 square yards.

MAP EXHIBITION.—The Royal Institution of Chartered Surveyors, in collaboration with the British Council, hopes, if the French strikes permit, to exhibit at the Sorbonne in Paris from to-day, August 28th, to September 6th, a selected part of the modern section of the exhibition "Five Centuries of Maps and Mapmaking," which has attracted a great deal of attention in London in recent months. It has been suggested that selections from this exhibition shall also be shown in other countries.

ELECTRICIANS' STRIKE.—Contracting work in various parts of the country has been slowed down this week by a strike of electricians. The stoppages which have occurred are supported by the Electrical Trades Union, and earlier in the week it was reported that they would continue until the National Federated Electrical Association was willing to offer a wage increase. But it was said, subsequently, that the union would call off the strikes if the employers' association would reopen negotiations on wages. By the middle of the week it was stated that about 1400 electricians on ten important building projects were participating in the strike. As we go to press it is understood that conciliation officers of the Ministry of Labour are discussing the matter with the union officials, following talks with representatives of the employers' association.

IRON AND STEEL INSTITUTE.—A special meeting of the Iron and Steel Institute is to be held in the Netherlands from September 30th to October 7th. The programme includes visits to iron and steel plants, laboratories, and shipbuilding and engineering establishments in Amsterdam, Ijmuiden, Utrecht, Delft and Rotterdam. No special papers are to be presented at the meeting, but there is to be a technical session at the Grand Hotel Krasnapolsky, Amsterdam, at which a review of the iron and steel industry in the Netherlands will be given, followed by a showing of technical films.

MODEL BUILDING BY-LAWS.—A new impression of the model building by-laws, issued by the Ministry of Housing and Local Government, which is substantially a reprint of the edition of 1952, has now been published and may be obtained from H.M. Stationery Office. The main purpose of this new impression—the 1953 edition—is to cut out wasteful work. The model as originally issued included six by-laws which have, in practice, proved to be seldom used, i.e. those relating to elevation of sites and the factory chimney clauses, and they have been removed to an appendix.

DEMONSTRATION OF "ARDOLOY" TOOLS.—We are informed by Alfred Herbert, Ltd., of Coventry, that for two weeks commencing September 14th next, it is proposed to hold demonstrations of "Ardoloy" tools at its works. In the course of these demonstrations the tools will be used on modern machine tools on actual production work involving heavy, medium and light finishing cuts. All grades of "Ardoloy" will be shown cutting a variety of materials, including non-ferrous, cast iron and different steels. The company has issued an invitation to all engineers interested in machining to attend the demonstration.

COAL PRODUCTION.—The latest figures issued by the Ministry of Fuel and Power about coal production in Great Britain show some recovery from the effect of miners' holidays. Last week, production from the deep mines was 3,958,200 tons and from opencast workings 235,000 tons, making a total of 4,193,200 tons, compared with 3,680,600 tons in the week ended August 15th. Last week, the deep-mined tonnage lost as a result of recognised holidays was estimated at 235,200 tons, compared with 729,400 tons in the preceding week. In the first thirty-three completed weeks of this year coal output, deep-mined and opencast, has amounted to 138,715,100 tons and is thus about 2,000,000 tons less than the amount gained in the comparable period of last year. Distributed coal stocks on August 15th totalled 15,307,000 tons, compared with 17,344,000 tons on August 16, 1952.

A MINE CAR STOP BLOCK.—A mine car stop block, which reduces damage to mine cars, has been designed by Mr. J. V. Cumberbatch, manager of Littleton Colliery, Cannock, Staffs. The block is a development from the ordinary type of scotch, which is raised and lowered automatically between the rails. These stops usually act on the wheels or axles of the cars, and in heavy mine cars this practice causes serious wear, particularly on wheel bearings. The stop block developed at Littleton Colliery is designed to catch a dummy axle on the cars, and it has two buffers, each comprising a sleeve and plunger. The shock when stopping a car is absorbed by rubber blocks in each plunger. Tests under operational conditions have shown that the two shock absorbers are compressed from 2½in to 2¼in by the impact of a gross load of 4 tons travelling at 3ft to 4ft a second. This block has been installed at thirteen stopping points in Littleton Colliery, and we are informed that in one instance it has been the means of dispensing with retarders.

NORTHAMPTON POLYTECHNIC PROSPECTUS.—We have received from the Applied Chemistry Department of the Northampton Polytechnic, St. John Street, London, E.C.1, a copy of its prospectus for the coming session, giving details of part-time day and evening classes. These classes are provided in general chemical technology, metallurgy, electrodeposition and metal finishing (including corrosion science), fuel technology, glass technology and glass working and clay technology. Classes in chemistry in preparation for the General Certificate of Education at both ordinary and advanced levels, the Intermediate B.Sc. (Eng.) and the University Preliminary examinations in engineering chemistry, in chemical engineering and in engineering metallurgy are also held in the department. These latter classes, organised in connection with National Certificate courses in engineering, are also suitable for students preparing for professional examinations (e.g. A.M.I. Mech.E., A.M.I.C.E., &c.). Two courses of special evening classes have also been arranged. One of these, commencing September 30th, consists of eight evening lectures on chemical and metallurgical thermodynamics, and the other of twelve lectures on refractories, commences on September 29th.

MANUFACTURE OF "CORRONEL B" ALLOY IN GREAT BRITAIN.—Adding molybdenum to nickel or to nickel containing small percentages of iron produces alloys which are strongly resistant to corrosion by hydrochloric and phosphoric acids, and to a lesser extent by sulphuric acid. The initial work on these alloys was done in the U.S.A. and Germany, and in the form of castings the alloys have been produced in this country for some years. Wrought forms are required, however, often for use in conjunction with castings, and it has been announced that Henry Wiggin and Co., Ltd., Birmingham, has begun the manufacture of material of this kind under the name of "Corronel B." Previous work on nickel-molybdenum compositions supplemented by investigations carried out in Birmingham shows that corrosion resistance improves with increased molybdenum content, and additions of up to 10 per cent of iron at the 30 per cent molybdenum level have no significant influence on corrosion rates. The composition of "Corronel B" is approximately 66 per cent nickel, 28 per cent molybdenum and 6 per cent iron. The new alloy can be satisfactorily worked, although it offers greater resistance to deformation than mild and low-alloy steels. "Corronel B" is highly resistant to hydrochloric acid at all concentrations and temperatures and has excellent resistance to sulphuric and phosphoric acids in certain ranges of concentration.

THE TELEPHONE SERVICE.—The General Post Office has recently installed the six millionth telephone in this country and says that there are now twice as many telephones in Great Britain as there were in 1938. Nearly 1,000,000 new connections have been made in the past three years. This has been done despite the unprecedented demand for telephone service and the restrictions on the money allowed to be spent for expansion. Last year, for instance, there were requests for nearly 350,000 installations. This expansion of the telephone service, the G.P.O. has pointed out, has been achieved by a comparatively smaller engineering staff. In 1923, when there were just over 1,000,000 telephones, the engineering staff numbered 22,000. On July 1st last the engineering staff numbered 64,000. This means that while the number of telephones since 1923 has increased sixfold, the number of engineering staff has increased only threefold. The main reason for the relative reduction in the engineering staff, it is claimed, lies in higher efficiency due to modern improvements, such as the installation of automatic mechanical and electrical devices, electronic cable locators and the use of up-to-date tools. The telephone waiting list is now 408,000, a reduction of 60,000 during the past twelve months. The G.P.O. goes on to say that the telephone density of Great Britain is now almost twelve per 100 of the population, and that there has been a tremendous increase in telephone traffic. In 1913, effective inland calls numbered 797,000,000; in the year ended March 31st last the figure was nearly 3500 million—more than four times as many. To handle the traffic there are now over 6000 telephone exchanges. There are some 19,000 telephone circuits over 25 miles in length in use in the public network.

Contracts

THE RAILWAY EXECUTIVE states that it has placed a contract valued at £286,000 with Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, for the manufacture and supply of electrical equipment for new rolling stock on the former Mersey Railway and the Wirral electrified lines.

THE CROWN AGENTS FOR THE COLONIES have placed an order with Mirrlees Bickerton and Day, Ltd., for two diesel alternator sets for the Gold Coast Electricity Board power station at Sekondi. Each set will consist of a Mirrlees "KS.7," seven-cylinder, vertical, turbo-charged diesel engine, developing 1331 b.h.p. at 375 r.p.m., coupled to a Brush 6000V, 50 cycles, three-phase alternator, the output of each being 750kW, 937·5kVA at 0·8 power factor.

Personal and Business

MR. R. M. HILARY will shortly take up an appointment with D. Napier and Son, Ltd., as commercial manager.

MR. J. R. M. POOLE has relinquished his position as chief architect to the Timber Development Association to take up an appointment in Government service.

MR. W. E. JOHNSON has been appointed head of the research division and a special director of Power-Samas Accounting Machines, Ltd.

RICHARD SUTCLIFFE, Ltd., Horbury, Wakefield, states that Mr. R. O'Brien, production manager, has joined the board.

MR. FRANK SPICER has been appointed general manager of Rushtons (Leeds), Ltd., Roundhay Road, Leeds, 8.

GEO. W. KING, Ltd., has now completed the final stages of its removal from Hitchin to new premises at Argyle Works, Stevenage, Herts.

MR. F. E. HOLMES has been appointed technical representative with responsibility for the sales department of Technical Designs, Ltd., 46, Brook Street, London, W.1.

HIGGS MOTORS, Ltd., Witton, states that Mr. A. C. J. Loat has joined its London sales staff as technical engineer. He will be responsible for districts to the south of London.

MR. HAROLD DREW, chief engineer of Vauxhall Motors, Ltd, has been appointed assistant chief engineer of General Motors Overseas Corporation, with headquarters in Detroit. Mr. Maurice Platt, executive engineer of Vauxhall Motors, Ltd., succeeds Mr. Drew as chief engineer.

THE SCUNTHORPE ROD MILL, Ltd., states that, by arrangement with the Iron and Steel Holding and Realisation Agency, its board has been reconstituted, Sir Charles Bruce-Gardner, Bart., is the chairman, the other directors being Mr. N. R. R. Brooke, Mr. W. L. James, and Mr. K. S. Peacock. This rearrangement follows the transfer of the company's entire share capital to John Lysaght's Scunthorpe Works, Ltd.

British Patent Specifications

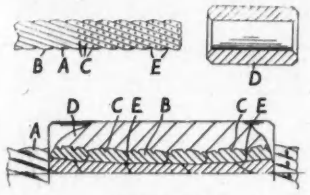
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

POWER TRANSMISSION

694,186. September 1, 1950.—SECURING AN ATTACHMENT PIECE TO A WIRE CABLE, Bowden (Engineers), Ltd., Bowden Works, Victoria Road, Willesden Junction, London, N.W.10. (*Inventor: Walter Arthur Melsom.*)

Referring to the drawings, the concentric lay cable *A* has the end portion of the zinc-coated high-tensile steel wires *B* of its outer surface formed with multiple indentations *C*, on one or more helices around the exterior formed by dies. The indented end portion of the cable is introduced into a mild steel attachment piece *D* which is contracted round the cable by



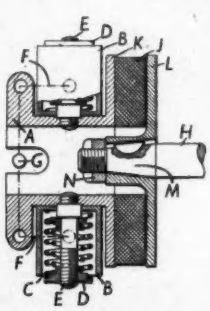
No. 694,186

swaging dies. This causes the metal of the attachment piece to flow into the indentations and into the external helical grooves *E* formed by the wires of the cable so that a resistance to parting of the piece from the cable, additional to the frictional resistance set up by the frictional grip of the piece with the cable, is set up, dependent on the skin shear resistance of the metal of the piece. Any tendency for the end piece and the cable to be relatively rotated is considerably reduced.—*July* 15, 1953.

INTERNAL COMBUSTION ENGINES

694,152. December 3, 1951.—CENTRIFUGAL GOVERNORS FOR FUEL INJECTION PUMPS, Hans Deckel, Irmgardstrasse 20, Münich-Solln, Germany; and Friedrich Wilhelm Deckel, Garatshausen 22, Post Tutzing, Germany.

In reference to centrifugal governors for fuel injection pumps of internal combustion engines, an object of the invention is to produce a simple satisfactory damping device. In the drawing the centrifugal governor is shown on a hub *A*; it consists, as shown, of two weights *B* working in conjunction with



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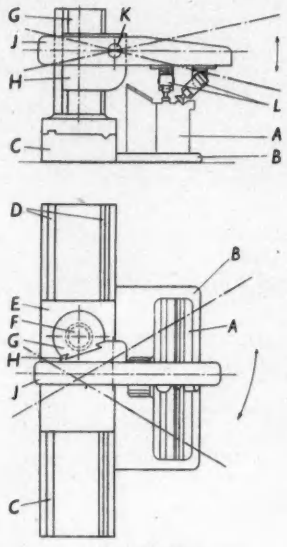
governor springs *C*. The springs abut with their outer ends on spring plates *D* arranged on pins *E* in the hub. The radial motion of the governor weights during running is transmitted by means of bell crank levers *F*, shown in broken lines, which are pivoted at the hub and are connected to a cross bolt *G*, which itself is connected by intermediate members with the mechanism to be governed. The hub *A* is driven by the shaft *H* through a damping element to prevent torsional and other vibrations from reaching the governor. Accordingly, the hub *A* is freely supported on the shaft through an annular disc *J* of rubber bonded to a flange *K* of the hub and to a second flange *L* keyed on the taper end *M* of the shaft *H* and secured there by a nut *N*. A modified construction is also shown in the specification.—*July* 15, 1953.

MACHINE TOOLS

694,697. October 16, 1951.—MACHINING PLANE SURFACES, Vereinigte Oesterreichische Eisen und Stahlwerke Aktiengesellschaft, Muldenstrasse 5, Linz a. Donau, Upper Austria.

The invention provides an improved machine suitable both for the rough machining and the finish machining of guide elements, with plane surfaces.

In accordance with the drawings the workpiece *A* is fixed on a stationary worktable *B* adjacent to the machine bed-plate *C*. The bed-plate has guides *D* on which a support *E* can slide in the longitudinal direction of the surfaces to be machined. Rigid with the support *E* is a column *F* on which a post *G*



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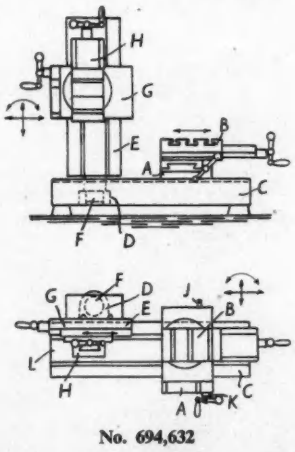
is rotatably mounted. On the post is a vertically adjustable slide *H* carrying a jib or outrigger *J*, which is hinged in a vertical plane about a horizontal axle *K*. Tool holders are mounted on the jib. Two such holders *L* are shown. Each can be adjusted lengthwise along the jib and also angularly. In modifications shown in the specification the workpiece is not placed on a stationary worktable but is clamped on a slide, which moves along a bed-plate. The column in this arrangement is stationary, and carries a rotatable post, as well as the outrigger and tool holders. The tool holder carried on the outrigger is rotatable on an axis perpendicular to the axis of rotation of the tool.—*July* 22, 1953.

694,632. April 12, 1949.—MULTI-PURPOSE MACHINE TOOLS, Hans Luce, Hainstück 1, Herbornseelback, Germany, and H. Hommel G.m.b.H., Elbestr. 19, Frankfort-on-Main, Germany.

The object of the invention is to provide a machine tool with which it is possible to impart to the workpiece and/or tool any movement which may be necessary as in all known machine tools so that turning, milling, planing, grinding or boring work of any desired arched or inclined surfaces is possible. As shown in the drawings, a compound slide rest consisting of a bottom slide *A* and a top slide *B* is so mounted on a bed *C* constructed as a smooth clamping



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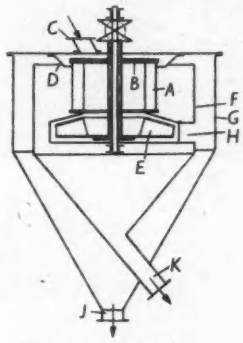
plate, that it can be longitudinally displaced along the bed and held fast in any position. The top slide *B* is rotatable through 360 deg. with respect to the bottom slide. The bed *C* has on the rear side near the head end a bearing socket *D* in which a second bed *E*, which may be a rack pillar, is rotatably mounted with a thrust journal *F*. The bed *E* also supports a compound slide rest consisting of a bottom slide *G* and a top slide *H*, and corresponding in construction to the compound slide rest *A* and *B*. The top slide *H* is rotatable through 360 deg. with respect to the bottom slide and is readily removable For the displacement of the two bottom slides on the two beds, the beds may be provided with racks each engaged by a pinion of one of the bottom slides. The guiding arrangement is so constructed that the bottom slides can be mounted on the beds when they are turned through an angle of 180 deg. If the bed *E* is constructed as a rack pillar, the guide member displaceable on it carries the bottom slide, which supports a rotatable top slide. If the lower slide rest is turned through 180 deg. when mounted on the bed *C*, the rear end *J* of the working spindle *K* of the bottom slide *A* is located at the front of the bed, and the spindle can then be coupled through a pick-off angle gear and a cardan shaft with a gearbox which can be mounted on the end *L* of the bed, or with any other drive. This step permits automatic facing, if a headstock is mounted on the bed *A*, with a faceplate to receive the workpiece and with a turning tool held on the compound slide rest *A* and *B*; while with a grinding disc held by the headstock and a workpiece clamped on the slide rest, the machine can be operated as an automatic surface grinding machine. The construction is completed by the usual machine tool accessories, such as headstock, tailstock overhanging worktable, circular table, gearbox and the like, all the parts being so made that they can be mounted, according to requirement, either on one of the two beds or on one of the top and bottom slides. The headstock can be driven by an electric motor, while if the machine is employed as a drilling machine a normal electric hand drilling machine can be clamped on the slide rest of one of the beds.—*July* 22, 1953.

SIEVING AND SEPARATING APPLIANCES

694,558. March 26, 1952.—SEPARATING DEVICE FOR SOLID MATERIALS, Aktiengesellschaft für Unternehmungen der Eisen und Stahlindustrie, Essen, Germany.

The invention relates to a pneumatic separating device for powdered materials. The drawing shows a vertical section through one form of the device. Above the separating wheel *A*, which is provided with paddles, is a distributing plate *B*, which rotates with it and serves as a feed and distributing device. The material to be separated is fed by a funnel *C* to the centre of the distributing plate, and by its rotation is uniformly subdivided, thrown against a stationary conical deflector wall *D* and reduced to powder. It then trickles as a uniform film through



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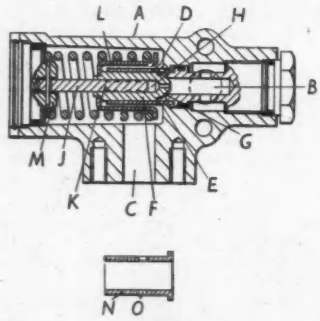
the annular gap at the base of the deflector wall, and downwards along the periphery of the separating wheel. The material is then entrained by the air current produced by a fan *E* beneath the separating wheel, and subjected to the action of the paddles of the separating wheel. Due to the suction produced by the fan a partial vacuum is produced in the space surrounding the separating wheel *A*. Air enters this space from above, around the upper edge of a funnel *F*, so that the material trickling downwards from the deflector wall *D* and the air current flow substantially in the same direction. This is important for attaining a complete separation. The finer material is thus deflected and drawn into the interior of the separating wheel and through the fan. The fan has a spiral housing which communicates with an annular space *H* formed between the funnel *F* and an outer funnel *G*. The finer material is flung into this space and leaves the funnel *G* through an outlet *J*. The coarser material falls into the inner funnel *F* and emerges through the outlet *K*.—*July* 22, 1953.

VALVES

694,662. December 14, 1950.—HYDRAULIC RELIEF VALVE, The Plessey Company, Ltd., 56, Vicarage Lane, Ilford, Essex. (*Inventor: Frederick Baines.*)

The invention relates to a hydraulic relief valve usable either as a normal relief valve or a differential relief valve. Referring to the drawing, a valve body *A* has an inlet *B* and an outlet *C* for the admission and discharge of pressurised liquid. A

valve guide *D*, when used as a simple relief valve, has a series of circumferential apertures or discharge outlets *E* immediately behind the seating. The valve is removably fitted to the body *A* in such a manner that the liquid can flow through the apertures *E* from the inlet *B* to the outlets *C*. A poppet valve *F* moving axially in the valve guide *D* closes upon a seating *G*. The poppet valve has a central bore *H* to receive a spindle *J*. The portion of the spindle inserted into the valve *F* has several annular grooves *K*, and rubber rings fitted into these grooves are a close fit with the bore. Abutting against the outer end of the valve is a thimble *L*. A compression spring inserted over the valve spindle *J* engages at one end a flange formed upon the thimble, and at the other end



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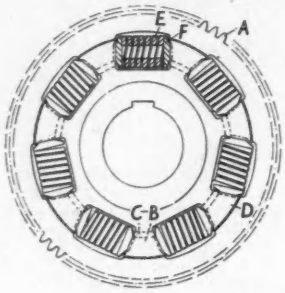
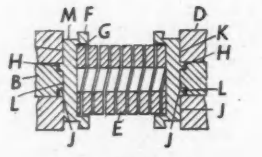
a nut *M* in the end of the valve body. The valve is normally held upon its seating under the spring loading, which can be varied by turning the nut. With this construction the circumferential ring of apertures *E* are immediately behind the valve seating *G*. When the valve is intended to be used as a differential valve the valve components are removed from the valve body and the valve guide *L* is replaced together with the other components by a valve guide *N* having a series of discharge outlets *O*. The arrangement is such that upon reassembly the outlets *O* are at the rear of the stepped face of the valve *F*. In each arrangement the rubber rings on the valve stem are pressed against the surface of the valve bore under the influence of the pressures acting upon the valve, thus eliminating " chatter."—*July* 22, 1953.

RAILWAY ENGINEERING

694,883. December 29, 1950.—RESILIENT POWER TRANSMISSION WHEELS, The Hunslet Engine Company, Ltd., Jack Lane, Leeds, 10, and John Frederick Alcock, of the company's address.

Referring to the drawings, the wheel shown comprises an outer annular and toothed portion *A*, having around its inner periphery a central flange *B* designed to lie within a corresponding groove *C* in the central portion *D* of the wheel. Both portions are gapped at a number of positions to enable the portions to





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be assembled. After assembly, springs *E* are inserted in the gaps. At each end each spring is provided with a metal pad *F*, as shown in the lower view. One side of each pad is substantially flat, and has formed on it a pair of narrow transverse ribs *H* which enter the adjacent end of the circumferential groove *C* in the central portion of the wheel. These ribs are parallel with each other and accommodate between them a short tenon-like projection *J* on the adjacent end of the flange *B* of the outer wheel portion. The side of the pad thus provides a pair of abutment surfaces *K* and *L* for the adjacent ends of the gaps in the two wheel portions, and the ribs *H* on the pad serve to prevent lateral displacement of the pad after assembly. The arrangement is such that when the wheel is not under a torsional load each pad bears at one side against the adjacent ends of the gaps in the two wheel portions *B* and *D*, as shown. But when the wheel is under load, causing relative angular movement of the wheel portions (in either direction), the portion *B* is separated from one of the pads, and the portion *D* is separated from the other pad. At all times, however, the ribs *H* prevent lateral displacement of the pads. To facilitate the insertion in position of the assembly comprising a spring and a pair of pads, a step *M* is formed along each of a pair of opposite edges of the pad to accommodate a clamp by which the assembly can be held together (with the spring compressed). After insertion in position, the clamp is detached, leaving the spring free to expand and hold the pads in place. By the invention, the securing of the springs in position is effected in a simple and convenient manner.—*July* 29, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, *Park Street, London, W.*1.

CABLES AND FLEXIBLE CORDS FOR ELECTRICAL EQUIPMENT OF SHIPS (INCLUDING ELECTRICAL PROPULSION) (PD.1665)

Amendment No. 2, August, 1953, to No. 883 : 1949. Price 3s. This amendment brings B.S. 883 into line with B.S. 7 : 1953 as regards insulation and sheath thickness for vulcanised rubber-insulated cables. It also introduces a range of 250V mineral-insulated, copper-sheathed cables, having up to seven cores, similar to the 660V cables already included. Tables of overall diameter with tolerances are also specified.

WIRE ARMOURED CABLES (VULCANISED RUBBER-INSULATED) FOR COLLIERIES

No. 2008 : 1953. Price 5s. This new standard deals with twin and three-core, 250V colliery lighting cables (other than for coal face lighting), as well as 660V and 3300V shaft and roadway cable. The insulation thicknesses are identical with the corresponding cores in B.S. 7 : 1953. Dimensions are specified for each size of cable with single-wire or double-wire armouring, and served overall with hessian tape, or taped and braided. In order to achieve the required conductance of the armouring it is permissible to include copper wires up to a specified maximum. The physical and chemical test methods and requirements are based on the corresponding sections of B.S. 7.

COTTER SLOTS AND QUICK-RELEASE TAPERS

No. 1660 : Parts 2 and 3. Price 4s. each. These standards comprise two further parts of the series appearing under the general title of B.S. 1660, " Machine Tapers," of which Part I, " Self-Holding Tapers and Gauges for Self-Holding Tapers " was published in 1950. Part 2 specifies the dimensions of cotter slots intended for use with the tanged Morse taper shanks and sockets standardised in Part 1, and also gives details of gauges for the verification of the slots. Part 3 deals with quick-release tapers, and the dimensions specified are based on those for the most commonly used American steep tapers as employed on spindle noses and arbors for milling machines. Basic dimensions are specified for taper Nos. 30, 40, 50 and 60 ; the essential dimensions of spindle noses and arbors incorporating these tapers are also given and provisions for suitable gauges are included.

ACCEPTANCE TESTS FOR TURBO COMPRESSORS AND EXHAUSTERS

No. 2009 : 1953. Price 10s. This new standard forms, with B.S. 1571, " Acceptance Tests for Positive Displacement Compressors and Exhausters " ; B.S. 707, " Testing of Mine Fans," and B.S. 848, " Testing of Fans for General Purposes," a series of codes for testing plant for the movement of air and other gases. It should be noted that arrangements are being made at the present time for the preparation of revision of B.S. 707 and B.S. 848. This standard specifies methods of test for uncooled and cooled axial-flow and centrifugal compressors and exhausters, both when the test and guarantee gases are the same and when they are different. It also specifies methods of measurement and deals with the instruments to be used. It then specifies the method of correcting the test results to allow for the difference between test and guarantee conditions, so as to provide an agreed basis by which guarantees given by manufacturers can be verified, or by which comparisons of the performance can be made. It also contains a section on definitions and symbols, and clauses on permissible deviation, duration of test, induction motor drive, power consumption, and the measurement of pressure, temperature, air flow and speed. To apply the code it is necessary to know the gas constant and the ratio of the specific heats for the test and guarantee gases. Methods of calculating these quantities for a mixture of gases, illustrated by examples, are given in Appendix A, which also includes a table of constants for a number of gases. Five detailed examples are given to illustrate the application of the code, and Appendix B, the theoretical basis of the code, explains the basis of the correction factors used. Charts required for calculations and diagrams of typical test layouts are also included.

Launches and Trial Trips

CORMOOR, steam collier ; built by Hall Russell and Co., Ltd., for William Cory and Son, Ltd.; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in, deadweight 4600 tons ; raised quarter deck, five self-trimming holds, steam deck machinery ; one direct-acting triple-expansion " North-Eastern Reheat " steam engine, 1100 i.h.p., taking steam at 220 lb per square inch from two cylindrical coal-burning boilers. Trial, August.

RATHLIN HEAD, cargo liner ; built by Harland and Wolff for the Ulster Steamship Company, Ltd.; length between perpendiculars 405ft, breadth moulded 58ft 9in, depth moulded to shelter deck 39ft, gross tonnage 7350 tons ; two complete steel decks, seven watertight bulkheads, five cargo holds, steam deck machinery ; one set of double reduction geared turbines, 5000 s.h.p., two Babcock and Wilcox, oil-fired, water-tube boilers supply steam at 260 lb per square inch and 625 deg. Fah.; two 30kW steam-driven generators, one 30kW diesel-driven generator. Launch, August 10th.

PATINGA, cargo ship ; built by Alexander Stephen and Sons, Ltd., for the Peninsular and Oriental Steam Navigation Company ; length 469ft 6in, breadth 64ft 6in, depth 42ft, load draught 27ft 4in, deadweight 9950 tons ; seven watertight bulkheads, five cargo holds, electrically driven deck machinery, three 300kW and one 150kW diesel-driven generators ; one set of triple-expansion double reduction geared turbines, 9000 s.h.p. at 104 r.p.m. of propeller, service speed 16 knots, Foster Wheeler " D " oil-fired water-tube boilers supply steam at 500 lb per square inch and 800 deg. Fah. Launch, August 11th.

BORDER KEEP, oil tanker ; built by the Blythswood Shipbuilding Company, Ltd., for the Lowland Tanker Company, Ltd.; length between perpendiculars 515ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, 16,000 tons deadweight ; twenty-seven main cargo oil tanks, two pump rooms, four 500 tons per hour cargo pumps ; Rowan-Doxford two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p., two oil-fired Scotch boilers. Launch, August 12th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 11th to 14th.—The University, Nottingham 28th Annual Conference.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 30th.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), W.C.1, " The Impact of Communication Theory on Television," D. A. Bell, 6.30 p.m.

ENGINEERS' GUILD

Thurs., Sept. 24th.—METROPOLITAN BRANCH : Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Oct. 6th.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, Members' Papers, 7 p.m.——LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, W.C.2, " Patterns, Casings and Foundry Work : An Introduction," Barnet Levy, 7 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 9th.—Manson House, 26, Portland Place, London, W.1, " Autofining," F. W. B. Porter, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Sept. 16th.—N.W. CENTRE : Victoria Hotel, Wigan, " The Use and Abuse of Fuels," W. E. P. Johnson, 7.30 p.m.
Thurs., Sept. 17th.—LONDON CENTRE : Visit by party of members to the main workshops, The Thames Valley Traction Company, Ltd., Reading, Berks, 1.45 p.m.——YORKSHIRE CENTRE : Hotel Metropole, King Street, Leeds, 1, " Vehicle Maintenance from the Aspect of Safety," A. H. Dack, 7.30 p.m.
Tues., Sept. 22nd.—N.E. ENGLAND GROUP : Royal County Hotel, Durham City, " The Maintenance of High-Speed Diesel Engines," H. L. Parrish, 7 p.m.
Wed., Sept. 23rd.—LONDON CENTRE : Visit by party of members to the works of Scammell Lorries, Ltd., Watford, Herts, 10.45 a.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 23rd.—Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, Presidential Address, R. C. Bond, 5.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues. to Fri., Sept. 8th to 18th.—LONDON : Anglo-American Conference.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Thurs. to Sat., Sept. 17th to 19th.—Autumn Meeting in Manchester.